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CALYX END STRUCTURE IN THE GRAVENSTEIN APPLE[1]

BY HUGH P. BELL[2]

Abstract

The development and structure of the calyx end of the Gravenstein is compared with that of a number of other varieties. This comparison indicates:—(i) that the calyx end of the Gravenstein exhibits an unusual degree of variation in its mode of development; (ii) that at maturity it is usually composed of a tissue which is exceptionally fissured and porous; (iii) that most of these fissures and pores are radial slits; and (iv) that, as these openings are so unusually large and numerous in the Gravenstein, its calyx end must be structurally weaker than the corresponding structure in the other varieties. It is suggested that the prevalence of open core in the Gravenstein is due to this structural weakness of the calyx end.

Introduction

The studies of mouldy core of the Gravenstein apple carried out by Brittain and Eidt (1) and by Harrison (2) established a definite relationship between mouldy core and open core. Harrison (2, p. 367) put forward the suggestion that the prevalence of open core in the Gravenstein was due to the "constitutional weakness of the calyx end" in this variety. The present work was undertaken to determine whether the calyx end of the Gravenstein was structurally weaker than that of other varieties of commercially grown apples.

Collections and Technique

The development of the calyx end of the Banks Gravenstein was traced from November 1937 until September 1938. The varieties selected for comparison were Ben Davis, Stark, and McIntosh Red. Collections from these and the Banks Gravenstein were made once a month from November to February, twice during March and once a week from April to the end of August. Also, from blossom time during the first week of June until the end of August, weekly collections were made from the Blenheim, Crimson Gravenstein, Macoun, King, Delicious, Winesap, Bramley Seedling, Evangeline, and Ortley (Cleopatra). Permanent slides were made from all these collections and included both transverse and longitudinal serial sections through the calyx end of ovaries or young fruit. The usual paraffin methods were employed. The serial collections for each variety were taken from one tree only. For each collection a tree was selected that appeared to be normal in every way.

[1] *Manuscript received September 25, 1939.*
Contribution from the Department of Biology, Dalhousie University, Halifax, Nova Scotia, with financial assistance from the National Research Council of Canada.
[2] *Professor of Botany, Dalhousie University.*

To be sure that each tree was normal and typical of its variety, young fruit was collected from various other trees of the same variety. This material and that from the selected trees were compared while fresh by means of hand sections. Besides checking the suitability of the selected trees, the hand sections of fresh material provided information which could not be obtained from the permanent slides. In addition, valuable material was kindly loaned by Mr. K. A. Harrison of the staff of the Laboratory of Plant Pathology, Kentville, N.S. This consisted of collections from the varieties Ortley, Banks Gravenstein, Gordon Gravenstein, Stark, Evangeline, and Wagener. In 1938 the period of full bloom for the orchard at the Kentville Experimental Station was about June 2.

Nomenclature

In Harrison's paper (2, p. 359), the terms describing the structural units at the calyx end are clearly defined. Three of his definitions are as follows:—

Calyx tube, sometimes called "Calyx cup." The cavity formed by the union of the bases of the sepals and extending from the sepals to the point of union of pistil and flesh.

Style tube. A passageway through the centre of the style that connects the core with the calyx tube. This was described by Miss Tetley from the variety Bramley's Seedling.

Open core. A core with an opening connecting it with the "calyx tube". Includes all breaks in the continuity of the tissue that permit penetration by saprophytic fungi. Replaces "open calyx tube" because it is considered more descriptive and cannot be confused with "open calyx".

These definitions have been followed in the present paper. Also the terms "up," "upward", and "above" in descriptions of flower or fruit structure have reference to distal portions and similarly "down", "downward", and "below" refer to proximal portions.

Structures and Period of Development to be Described

The normal apple at all stages of growth is excellently described by Kraus (3, 4), so it is unnecessary to repeat his descriptions. After examination of the early collections, it was apparent that there was no need to discuss the development that occurs before the second week of May or to deal with any structures other than those at the calyx end. To be more explicit, this article deals only with the part of the ovary between the carpellary cavities and calyx tube and traces the development of this portion from just before the middle of May until the fruit is mature in the autumn.

Comparison of Development

Early Development for All Varieties

About the second week of May, that is, three weeks before the time of full bloom, the structure of the calyx end of the young flower is fundamentally similar for all varieties of apple studied. At that time, the top of the ovary

consists of a cylinder of tissue, through the centre of which runs the open style tube. This style tube is typical and practically the same for all varieties (Fig. 2). It is usually oval in cross section but sometimes round and from it radiate ten vertical slits. Five of these are upward continuations of the carpellary cavities (*d*, Fig. 1), and may be recognized by the presence of the dorsal carpellary bundle. The five alternating with these are downward continuations of the spaces between the styles (*c*, Fig. 1). During the early development, the upper portions of the former and the lower portions of the latter become closed by the subtending surfaces of epidermal cells coming together, but the original locations of the radial fissures are indicated by ten double rows of epidermal cells radiating from the style tube. Sometimes the two sets of radial openings overlap, but usually, by the middle of May, only one set occurs as openings at any one level. Fig. 2 is of a section through the upper portion of the style tube. In this the continuations of the spaces between the styles occur as five radial fissures, but the continuations of the subtending lining surfaces in the carpellary cavities are in contact. The style tube at this time is continuous, and has an average transverse measurement at its narrowest part of 150 by 40 μ.

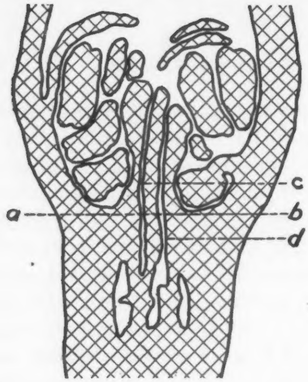
During the three weeks preceding full bloom, growth at the calyx end of the apple is such that there is a tendency for part of the passage provided by the style tube to become closed. The place where the closing begins is about on a level with the lowest part of the calyx tube or calyx cup (*a-b*, Fig. 1). This consists of a depressed circular groove around the united style bases. It is on a level with the bottom of this groove that the closing of the style tube first occurs.

Later Development in Varieties Used as a Check

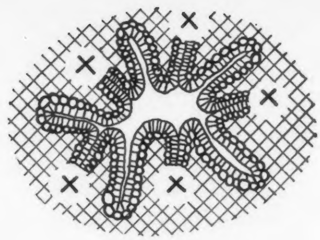
Shortly before and during blossom time, the development varies from variety to variety; but, with the exception of the Gravenstein, it is quite constant for each variety. The different modes of development produce different types of calyx end structures. These may be grouped into three classes, namely:— (I) those with a completely closed style tube; (II) those with a central opening or style tube persisting; and (III) those with the style tube closed but the surfaces of some of the radial slits failing to fuse, leaving a varying number of radial openings.

The first type, with complete union of all tissues and hence complete closing of the style tube, is well represented by the Stark and Ben Davis and is illustrated in Fig. 3. Throughout June and even into July the united epidermal layers may still be recognized, but subsequent growth of cells makes their recognition difficult. After the style tube was apparently closed, very thin hand sections of fresh material were cut and an attempt made to separate the tissues along the original line of union, but no separation could be affected. From this it may be concluded that in these varieties the union of cells is complete.

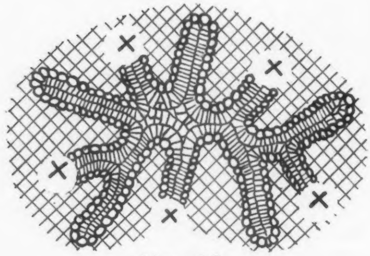
The second type, with an open style tube in the centre, is well represented by Bramley Seedling, and is described by Tetley (5). Other varieties in this



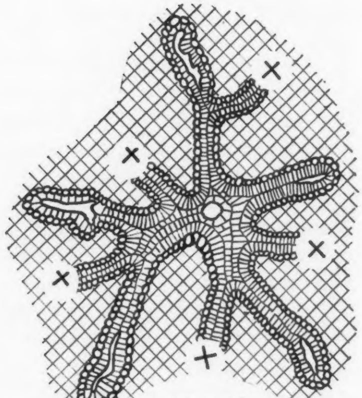
April 27
Fig. 1



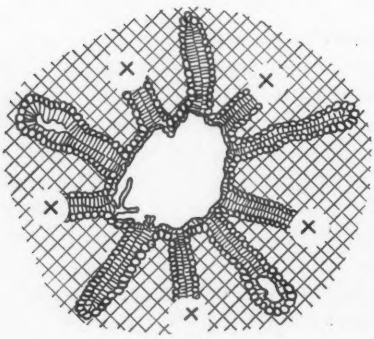
May 11
Fig. 2



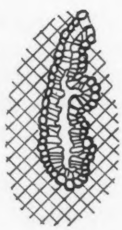
May 30
Fig. 3



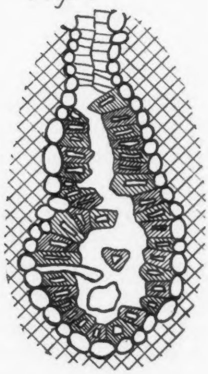
May 30
Fig. 4



July 9
Fig. 5



June 20
Fig. 6



July 4
Fig. 7

FIGS. 1 – 7. FIG. 1. *McIntosh Red, April 27; longitudinal section through the centre of apple flower still enclosed in winter bud; a–b, level of lowest part of calyx tube; c, downward extension of space between the styles; d, upward extension of a carpellary cavity;* ×*20.* FIGS. 2 – 7; *transverse sections of calyx end at level of a–b, Fig. 1; drawings semi-diagrammatic; epidermal cells and those of one adjacent layer indicated; the other tissue doubly cross-hatched; X, upward continuations of tissue lining carpellary cavities.* FIG. 2. *Ben Davis, May 11; style tube still open;* ×*105.* FIG. 3. *Stark, May 30; style tube closed;* ×*105.* FIG. 4. *Banks Gravenstein, May 30; downward continuations of spaces between styles open, forming radial fissures, also a small open style tube;* ×*105.* FIG. 5. *Crimson Gravenstein, July 9; a large open style tube, circular in cross section, also two small radial openings;* ×*105.* FIG. 6. *Banks Gravenstein, June 20; an open radial fissure similar to those in Fig. 4, but more advanced; epidermal cells elongating and walls of some thickening;* ×*105.* FIG. 7. *Banks Gravenstein, July 4; as in Fig. 6, but a later stage with walls of all epidermal cells lignified;* ×*385.*

class are Evangeline and Delicious. The style tube in these does not always remain circular in cross section. It is more frequently oval and at times it may divide into two or three tubes separated by thin partitions. Fig. 5 illustrates a calyx end with an open style tube that is circular in cross section. The open style tube is sometimes accompanied by small radial fissures (Fig. 5), but the central opening is larger and more prominent, and it differs from the others in that it provides a continuous open passage from the outside to the inside of the fruit.

The varieties of the third class, that is, those with the style tube closed but the surfaces of some of the radial slits failing to fuse, are fairly numerous and include the McIntosh Red and the Wagener. The failure to close is similar to, but usually less extensive than that illustrated for the Gravenstein in Fig. 4. Lack of fusion is much more common in the downward continuations of the spaces between the styles than in the upward continuations of the carpellary cavities. The fissures observed by Harrison in the Wagener (2, p. 366) were without doubt these partially closed radial slits. These radial apertures are at first lined by delicate epidermal cells, but as the fruit matures, these lining cells either grow into short stiff hairs or, by elongating uniformly at right angles to the surface and depositing a secondary thickening on the wall, form a layer of semi-columnar but distorted thick-walled cells. The hairs are more common for the central opening and the layer of thick-walled cells for the peripheral part of the radial opening, but they may be interspersed. In either case the cells become mature and inactive, so that tissue union between these subtending surfaces does not take place, for in the mature fruit the radial apertures are still present. These openings alone do not provide a passageway between the outside and the inside of the fruit, but, as partially closed and laterally located pores or pockets, are present in the tissue at the calyx end in a large number of varieties.

Later Development in the Gravenstein

The Gravenstein is different from the other varieties in two ways. First, there is a lack of uniformity in the method of growth, and second, when radial openings occur, they are usually larger and more numerous.

Sometimes the Gravenstein apple closes perfectly as in Class I (Fig. 3). Occasionally a continuous central style tube persists as in Class II (Fig. 5). This latter condition, however, is comparatively rare.

The majority of Gravensteins belong to Class III, having openings of varying sizes in some of the ten radial slits (Fig. 4). As in the other varieties, these spaces occur much more commonly in the downward extensions of the spaces between the styles than in the upward extensions of the carpellary cavities, but they are by no means uncommon in the latter. There is no uniformity in the number of slits that remain unclosed but it is seldom less than three, and occasionally some opening may be found in all ten rays. Sometimes the style tube closes completely, although large laterally placed radial apertures may be present in the same fruit. Sometimes the radial fissures are accompanied

by a small or large style tube; but usually a small style tube such as that illustrated in Fig. 4 is closed for a short distance, although it may remain as a very narrow passage through most of the tissue at the calyx end. The radial openings vary greatly in size. Their horizontal length varies from practically the whole extent of the ray (Fig. 4) to that of a small oval aperture at the distal end (Fig. 5). Also in vertical extent, they vary from a small closed pocket to a continuous vertical passage closed at one end only. But consideration of these great variations must not obscure the constant feature, namely, that in the Gravenstein these radial openings are unusually extensive and numerous.

It cannot be assumed, however, that because these radial openings are so large and numerous, that they provide a passageway from the outside into the carpellary cavity. In this respect the Gravenstein is not different from the other varieties. The downward continuations of the spaces between the styles usually close at the level of the top of the carpellary cavities proper and the upward continuations of the carpellary cavities usually close below the level of the base of the styles. In the intervening region, that is, between the top of the carpellary cavities and the base of the calyx tube, these two sets of openings may overlap and give to the tissue there a fissured or porous character, which must be a great source of weakness; yet, unless these radial openings connect with a central style tube, they, by themselves, do not provide a continuous passage from the outside to the inside.

As already stated, the radial fissures or pores do not close during the maturing of the fruit, but the lining cells grow into either hairs or elongated thick-walled cells. These thick-walled cells were conspicuous in the Gravenstein, and their progressive development is illustrated in Figs. 6 and 7. But it is evident that this thickening of the walls of the individual cells does not add to the general rigidity of the region, for the structural weakness of the tissue is the long open slits, and these are to be found even in the ripened fruit. Also, as the fruit enlarges, the soft surrounding cells tend to tear away from this stiff or rigid lining, producing additional openings. Thus instead of the thick-walled cells giving any strength to the tissue, they may be a source of weakness.

Using mature Gravenstein apples in which a split at the calyx end had produced an open core, an attempt was made to locate the origin and exact position of the split. It was found that these breaks did not always pass through the exact centre where the original style tube would be located, but their location might be slightly excentric or lateral through the tissue which would be occupied by the radial apertures. When once the fruit had cracked open, the tissues were so torn and otherwise changed that one could not be certain that the break had followed the line of an open radial fissure, but all the evidence suggested that this was the case.

Final Comparison

A comparison of the Gravenstein with the other varieties examined, indicates:— (i) that the calyx end of the Gravenstein exhibits an unusual degree of variation in its mode of development; (ii) that at maturity it is usually composed of a tissue which is exceptionally fissured and porous; (iii) that most of these fissures and pores are radial slits; and (iv) that, as these openings are so unusually large and numerous in the Gravenstein, its calyx end must be structurally weaker than the corresponding structure in the other varieties.

Discussion

The morphological evidence presented above parallels and partially explains the evidence of a different type presented by previous investigators. The large percentage of open core for the Gravenstein reported by both Brittain and Eidt (1) and Harrison (2) would be expected in a variety with such an exceptionally weak calyx end. The more frequent appearance of open core in the larger apple (2, p. 364) may be accounted for, since the larger the size attained, the greater the growth strains and the greater the likelihood of a break where weakness exists. That is, the fact that so many Gravensteins have a calyx end which is structurally weaker than that of other varieties explains why open core is so common in the Gravenstein, but still leaves unexplained why radial fissures close in some apples and remain open in others from the same tree.

Conclusion

The logical conclusion from the findings outlined above is that Harrison (2, p. 367) is correct when he suggests that open core in the Gravenstein is correlated with a "constitutional weakness of the calyx end" of that variety.

Acknowledgments

The author wishes to express his indebtedness to the Pathologist-in-Charge, Laboratory of Plant Pathology, Kentville, Nova Scotia, for laboratory space during two summers, and to the staff of the laboratory at Kentville for collections made throughout the winter of 1937–38. The figures were drawn by Miss Elizabeth E. Bligh, of Kentville, N.S.

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PHYSIOLOGIC RACES OF *USTILAGO HORDEI* (PERS.) K. AND S. IN ALBERTA[1]

By Wm. Semeniuk[2]

Abstract

The pathogenicity of four collections of *U. hordei* on four varieties of barley was determined in 1935, 1937, and 1938. Investigations conducted in 1935, involving 12 collections, indicated that the four used in the present investigation represented distinct physiologic races. The distinctions between these races appeared to be substantiated in 1937, but the 1938 results were conflicting. One race *(B)* is clearly distinct from the other three (*F*, *H*, and *L*), but the cause of the erratic behaviour of *F*, *H*, and *L* from year to year is obscure.

Introduction

Resistance to covered smut (*Ustilago hordei* (Pers.) K. and S.) and loose smut (*U. nuda* (Jens.) K. and S.) is being emphasized in the barley breeding work in progress at the University of Alberta. This paper is concerned only with the results of investigations on physiologic specialization in *U. hordei*. Results of investigations on comparative varietal reactions will be published later.

The existence of physiologic races in *U. hordei* has been reported by several investigators (1–5). Owing largely to difficulties in securing heavy infections and to a lack of agreement between results obtained in different years, some of the data published are little more than suggestive. Probably the most convincing evidence is to be found in a paper by Tapke (5), in which eight physiologic races are clearly distinguished. Striking differences in cultural characteristics have been demonstrated by Rodenhiser (4), and two of the cultural strains were found to differ in pathogenicity.

Material and Methods

In 1934, 12 collections of *U. hordei* were obtained from widely separated points in Alberta. Each collection consisted of a bulk sample of chlamydospores obtained from several infected spikes in one field. Thirteen varieties were inoculated with each of the 12 collections and grown in 1935. The results of this preliminary trial indicated that four of the collections differed with respect to their ability to infect the varieties Colsess, O.A.C. 21, Hannchen, and Trebi. These collections and the four varieties named provided material for further experiments.

To obtain inoculum for succeeding experiments, infected spikes, representing each collection, were gathered from each of the four varieties except, of course, from varieties on which no smut developed. The identity of the collections

[1] *Manuscript received October 30, 1939.*
Contribution from the Department of Field Crops, University of Alberta, Edmonton, Alberta, with financial assistance from the National Research Council of Canada.
[2] *Graduate Assistant, University of Alberta.*

was carefully maintained, but samples of individual collections secured from different varieties were bulked. In other words, no attempt was made to effect a separation of biotypes within a collection by means of the possible "screening" action of the different varieties.

The chlamydospores were threshed free by rubbing the infected spikes on wire cloth with a glass rod. The cloth and rod were sterilized before threshing each collection.

In all tests, the seed was partially dehulled before inoculation. The embryo was exposed by removing the lower part of the lemma with a small knife after soaking the seeds in tap water for about 20 min.

In 1935, the material was planted in eight-foot rows at the rate of 75 seeds per row. In 1937, only 50 seeds were planted in each row. In 1938, the rows were 10 ft. in length with 100 seeds in each row. Varieties and collections were randomized within each of the two replicates. When classifying the material, counts were made on a plant basis and no distinction was made between partially and completely infected plants.

The test was planted in 1936 also, but the degree of infection was so low that the results were worthless.

Experimental Results

The percentage infections by the four collections on four varieties and the numbers of plants on which the percentages are based are recorded in Table I. Each entry in the table represents a total of two replicates.

TABLE I

TOTAL PLANTS OF FOUR VARIETIES OF BARLEY AND PERCENTAGE INFECTION BY FOUR COLLECTIONS OF *Ustilago hordei*

Collection	Source	Year tested	Total plants (two replicates)				Percentage infected			
			Colsess	O.A.C. 21	Hannchen	Trebi	Colsess	O.A.C. 21	Hannchen	Trebi
B	Innisfree, Alberta	1935	104	86	106	112	2.9	0.0	52.8	52.7
		1937	47	54	31	50	4.2	0.0	25.8	46.0
		1938	159	161	122	192	3.8	0.0	67.2	49.5
F	Cooking Lake, Alberta	1935	93	24	119	71	30.1	8.3	0.8	0.0
		1937	46	51	28	38	17.4	0.0	0.0	0.0
		1938	156	155	113	171	63.5	1.9	65.5	59.1
H	Alaska	1935	123	94	117	121	13.8	13.8	0.0	0.8
		1937	59	57	41	62	0.0	8.8	0.0	0.0
		1938	163	163	167	179	43.6	3.1	40.1	58.6
L	Edmonton, Alberta	1935	133	141	132	130	36.1	5.7	48.5	35.4
		1937	47	51	20	42	51.1	0.0	30.0	23.8
		1938	168	164	164	165	63.7	0.0	41.5	60.6

On the basis of the data assembled in 1935 and 1937, the four collections may be distinguished by means of their relative ability to infect Colsess, O.A.C. 21, and either Hannchen or Trebi. The 1937 results agree very well with those obtained in 1935 except in the cases of collection *F* on O.A.C. 21 and collection *H* on Colsess. In 1938, however, the distinctions between collections *F*, *H*, and *L* practically disappeared. The identity of collection *B* was maintained by its inability to produce more than a slight infection on Colsess.

Discussion

Perhaps the most interesting, though disconcerting, feature of the results presented is the extent to which the classification of smut collections, based on 1935 and 1937 results, is altered by the 1938 results. The cause of the sudden change in pathogenicity in 1938 is obscure. It is probable that most, if not all, races of *U. hordei* are highly heterozygous with respect to pathogenic capabilities. Since segregation and recombination are involved in each generation of chlamydospores, complete uniformity of results from year to year is not to be expected. However, the segregation hypothesis is hardly likely to explain the difference between the 1935 and 1937 data and those obtained in 1938. The remarkable uniformity from year to year, of the data compiled by Tapke (5) is of interest in this connection. It is possible that seasonal differences in the environment may have favoured the multiplication of certain biotypes within the collections. This suggestion is, however, pure speculation.

Acknowledgments

Mr. W. H. Johnston, now Assistant Superintendent of the Dominion Experimental Farm, Brandon, Manitoba, secured the collections of smut and directed the 1935 tests. His contribution is gratefully acknowledged. The author is also indebted to Dr. K. W. Neatby, Professor of Field Crops, University of Alberta, for his assistance in the preparation of the manuscript.

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RELATION OF SUNSPOT PERIODICITY TO PRECIPITATION, TEMPERATURE, AND CROP YIELDS IN ALBERTA AND SASKATCHEWAN[1]

By L. P. V. Johnson[2]

Abstract

Coefficients of correlation (r) were calculated for sunspot data as related to annual precipitation and to temperature data from Edmonton, Calgary, Medicine Hat, Swift Current, Battleford, and Qu'Appelle; and as related to data on the yields of wheat, oats, and barley in Alberta and Saskatchewan. In all cases the correlation was negative, but only in the cases of precipitation at Edmonton, Calgary, and Battleford were the values significant. Data giving significant values of r are given graphical treatment.

It was concluded that while the sunspot cycle probably bears some causal relation to precipitation, and perhaps also to temperature and indirectly to crop yields, it, nevertheless, does not provide a basis for long-range weather forecasting owing to the confusing effects of other weather-determining factors.

The literature on sunspot periodicity in relation to terrestrial phenomena is reviewed briefly.

Introduction

The extent to which sunspot periodicity influences weather has been a controversial point for many years. Recently this controversy has become more active, owing, no doubt, to the increased popular interest in seasonal weather predictions, which has been occasioned by the recent widespread droughts on the Great Plains of North America.

It is the writer's opinion that many, if not most, of the differences in this dispute have arisen through the methods of data analysis used by some authors in attempting to establish high correlations between the variables. For example, the use of smoothed mean graphs (representing the average of the superimposed graphs of data from several cycles or periods of rise and fall) greatly exaggerates the true relation between the variables with respect to individual events of coincidental occurrence. Such exaggeration has led to over-emphasis, which, in turn, has added fuel to the controversial fire.

The present study represents the application of the coefficient of correlation and direct graphical methods to unmanipulated data in investigating the effective, directly apparent influence of sunspot periodicity on precipitation, temperature, and crop yields in Alberta and Saskatchewan.

Periodicity in Number of Sunspots

The number of observed sunspots varies greatly from year to year, showing a primary periodicity of about 11 years (Fig. 1 and Tables I, II, and III). Besides this primary periodicity a number of other cycles have been established,

[1] *Manuscript received October 18, 1939.*
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[2] *Forest Geneticist.*

notably that known as the double, Hale, or 22-to-23-year cycle. This cycle represents essentially an alternate variation in the intensity of sunspot maxima. Reference to Fig. 1 will serve to demonstrate that the alternate maxima of 1870, 1893, 1917, and 1937 are each higher than the maximum preceding. In this paper we shall designate these maxima as major and minor, respectively.

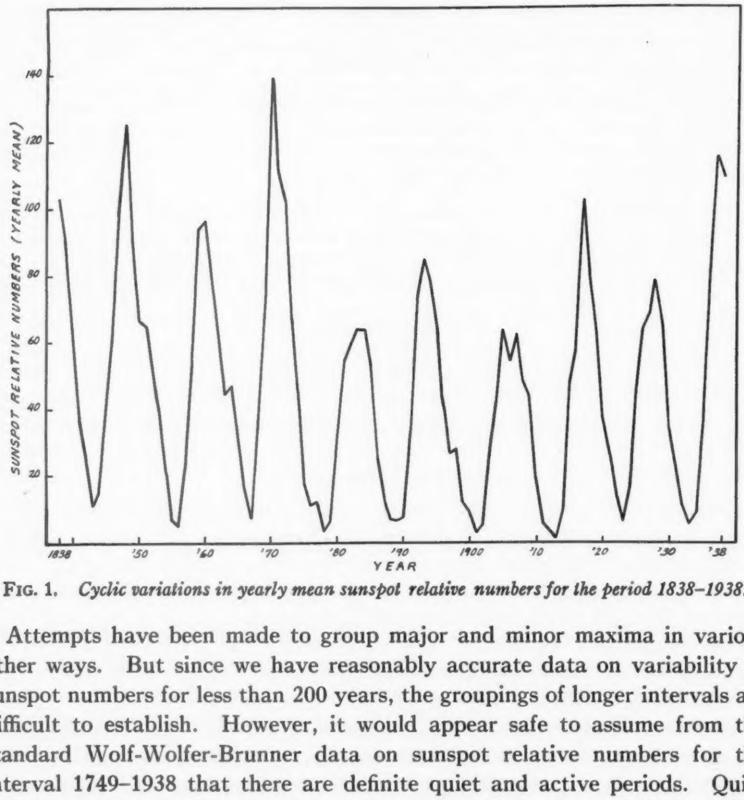

FIG. 1. *Cyclic variations in yearly mean sunspot relative numbers for the period 1838–1938.*

Attempts have been made to group major and minor maxima in various other ways. But since we have reasonably accurate data on variability of sunspot numbers for less than 200 years, the groupings of longer intervals are difficult to establish. However, it would appear safe to assume from the standard Wolf-Wolfer-Brunner data on sunspot relative numbers for the interval 1749–1938 that there are definite quiet and active periods. Quiet periods existed during the intervals, ?–1766, 1798–1833, 1878–1933; while active periods held during the intervals, 1766–1798, 1833–1878 with another commencing (possibly) in 1933.

Fig. 1 shows two major maxima and one minor maximum of the active period ending in 1878, and three major and three minor maxima of the quiet period 1878–1933. It will be noted that since the first maximum of the quiet period (1883) there has been a general upward trend in both major and minor maxima.

In Tables I, II, and III, references to major maxima are printed in capitals.

Effect of Sunspot Periodicity upon Terrestrial Phenomena

It is an established fact that periodic variations in numbers of sunspots produce appreciable effects upon certain electro-magnetic phenomena on the earth, e.g., the number and magnitude of magnetic disturbances, the brilliancy of aurorae, the strength of electric currents in the earth's crust, etc. (2, 16, 18).

The influence of sunspot periodicity on terrestrial weather, however, is much less apparent and, because of much conflicting data (possibly misinterpreted), the relation can hardly be said to be generally accepted as an established fact. In 1929 Dr. Carpenter (3) made the statement that "the verdict of the Mount Wilson Solar Observatory astronomers is that they can find *no relationship between sunspots and weather*" (italics mine). Some authors on this subject (2, 15, 16, 18) conclude that, while sunspots may have some effect, the influence is worthless as a basis of weather forecasting. Others (1, 5–14) take the stand that the sunspot cycle determines weather to an extent sufficient to warrant certain types of prediction. Certain members of the latter group claim that sunspots, operating through their effect on weather, have unmistakable influences on crop yields (9), tree growth (1, 9, 11, 12), fish catches (9), abundance and health of insects, birds, and wild quadrupeds (7, 9, 10), levels and times of freezing and break-up of ice in lakes and rivers (9), commodity prices (9), marriage rates (9), etc.

The means by which sunspots influence terrestrial phenomena is not definitely known. DeLury and co-workers (9, 10) state that emission of ultra-violet light from the sun varies directly with the number of sunspots. Since ultra-violet light is thought to ionize the upper terrestrial atmosphere, it is considered that liberated ions diffusing downward would cause electro-magnetic and meteorological changes observable on the earth. Thomson (18) declares, however, that there is no correlation between numbers of sunspots and intensity of ultra-violet radiation.

It should be stated that DeLury (8, 9) has found that in oceanic regions precipitation is greater at sunspot maximum (aquene response), while in inland regions precipitation is less at sunspot maximum (terrene response). Certain regions near the coast exhibit an intermediate or terraquene response in which aquene and terrene responses are blended in various ways. These responses have not been satisfactorily explained. Obviously, in making correlative studies on sunspots and precipitation, it is necessary to deal separately with data from regions of opposing response.

Correlation of Sunspot Periodicity with Precipitation, Temperature, and Crop Yield in Alberta and Saskatchewan

The great extent to which agriculture in the semi-arid region of Alberta and Saskatchewan is dependent upon the weather was emphasized by recent drought conditions. This fact prompted the present attempt to investigate possible influences of sunspot periodicity upon precipitation and temperature in the region. It has been possible to extend the study to include also the

influence upon crop production, since precipitation to a large extent and temperature to a lesser extent determine yields in the area.

Data were obtained on total annual precipitation and mean annual temperature at six meteorological stations situated in the semi-arid region. These stations, with date of first available data, are as follows: Edmonton, 1883; Calgary, 1885; Medicine Hat, 1884; Swift Current, 1886; Battleford, 1891; Qu'Appelle, 1884. The period from the dates given to 1938, inclusive, covers approximately five 11-year sunspot cycles.

Data were obtained on annual yield per acre of wheat, oats, and barley for the years 1898 to 1938, inclusive, a period covering somewhat less than four 11-year sunspot cycles.

(a) Source of data

Sunspot periodicity: Data supplied by Dr. R. E. DeLury, Ottawa. Solar Observations, Dominion Observatory, Ottawa.

Precipitation: Data sheets supplied by Mr. J. Patterson, Controller, Meteorological Division, Air Services, Department of Transport, Toronto.

Report of Conference on Conservation of Soil Fertility and Soil Fibre. Winnipeg, July 14–16, 1920.

Temperature: Data sheets supplied by Mr. J. Patterson, Toronto.

Crop Yields:

Saskatchewan. Report on acreage and condition of growing crops. Bull. 17, Dept. Agr., Northwest Territories, Regina, 1905.

Annual Report, Dept. Agr., Sask., 1906.

Final report on grain crops. Bull. 6, Dept. Agr., Sask., 1907.

Annual Reports, Dept. Agr., Sask., 1908, 1909.

Final reports on grain crops and livestock. Bull. 23, 29, 35, Dept. Agr., Sask., 1910, 1911, 1912 (summarizes data 1899–1912).

Annual Report, Secretary of Statistics, Dept. Agr., Sask., 1913, 1914, 1915, 1929 (summarizes data 1905–1928), and 1938 (summarizes data 1923–1937).

Alberta. Final report on grain crops and livestock, Bull. 8, Dept. Agr., Alta., 1910 (summarizes data 1899–1910).

Statistics of progress. Pub. Stat. Branch, Alta., 1929 (summarizes data 1906–1928).

General. Unpublished tables and work sheets supplied by Chas. F. Wilson, Statistician, Agricultural Branch, Dominion Bureau of Statistics, Ottawa.

(b) Precipitation–sunspot correlations

In Table I, yearly mean relative sunspot numbers are compared with total annual precipitation at the meteorological stations situated at Edmonton, Calgary, Medicine Hat, Swift Current, Battleford, and Qu'Appelle. The

TABLE I

YEARLY MEAN SUNSPOT RELATIVE NUMBERS COMPARED WITH PRECIPITATION DATA FROM SIX POINTS IN ALBERTA AND SASKATCHEWAN

Year	Sunspot relative number	Total annual precipitation in inches at						Mean of all points
		Edmonton	Calgary	Medicine Hat	Swift Current	Battleford	Qu'Appelle	
1883	63.7 max.	9.27	—	—	—	—	—	—
84	63.5	15.67	—	14.53	—	—	13.97	—
85	52.2	15.36	13.67	8.65	—	—	11.92	—
86	25.4	9.22	11.32	6.72	10.77	—	10.14	—
87	13.1	12.50	13.69	9.89	18.00	—	14.47	—
88	6.8	19.93	17.51	14.67	14.09	—	17.00	—
89	6.3 min.	8.16	11.59	7.96	10.46	—	10.54	—
1890	7.1	22.01	15.47	9.13	17.50	—	23.97	—
91	35.6	17.90	10.44	13.15	24.55	9.35	19.02	15.73
92	73.0	16.85	7.91	12.24	20.20	11.06	16.45	14.12
93	84.9 MAX.	17.87	11.05	14.60	14.54	10.93	16.35	14.52
94	78.0	16.13	11.70	13.14	9.66	13.47	12.52	12.77
95	64.0	14.68	15.12	14.13	12.33	12.01	15.29	13.93
96	41.8	15.24	16.05	18.18	14.11	12.93	21.63	16.36
97	26.2	14.55	20.58	17.27	16.24	16.53	12.65	16.30
98	26.7	10.90	16.21	15.90	15.25	14.25	21.65	15.69
99	12.1	20.89	26.15	22.28	19.38	18.42	19.27	21.06
1900	9.5	27.81	17.57	22.05	14.60	20.37	16.52	19.82
01	2.7 min.	27.51	22.31	20.80	18.58	16.07	26.47	21.96
02	5.0	20.86	34.57	13.68	17.64	13.49	24.37	20.77
03	24.4	21.06	22.77	9.90	18.38	16.06	20.09	18.04
04	42.0	18.87	11.89	9.70	12.84	16.60	22.22	15.35
05	63.5 max.	15.56	14.32	8.99	15.68	10.55	24.55	14.94
06	53.8	19.00	16.24	12.62	19.02	10.64	20.39	16.32
07	62.0	9.88	14.96	6.86	13.17	10.11	18.53	12.25
08	48.5	17.89	18.25	10.22	12.60	17.51	18.67	15.86
09	43.9	12.88	16.03	9.80	19.26	12.02	25.75	15.96
1910	18.6	14.93	12.03	7.55	10.13	8.75	19.02	12.07
11	5.7	20.67	19.47	16.14	14.29	20.47	20.61	18.61
12	3.8	20.18	21.32	10.38	14.62	14.84	18.06	16.57
13	1.4 min.	19.54	17.03	13.62	12.60	11.73	21.24	15.96
14	9.6	25.29	17.70	12.17	12.48	19.14	19.77	17.76
15	47.4	18.64	18.32	16.13	14.27	8.69	18.67	15.79
16	57.1	20.92	13.91	17.90	23.98	17.73	26.54	20.16
17	103.9 MAX.	15.25	11.44	11.13	11.92	8.20	16.69	12.44
18	80.6	17.86	9.12	10.01	12.22	9.76	15.53	12.42
19	63.6	16.43	11.98	7.64	12.33	10.26	17.92	12.76
1920	37.6	18.16	14.42	10.74	10.23	19.64	19.72	15.48
21	26.1	15.22	13.48	12.94	15.05	19.48	27.19	17.23
22	14.2	13.77	10.61	11.54	14.27	10.95	22.03	13.86
23	5.8 min.	17.44	23.87	15.46	16.38	14.70	27.05	19.15
24	16.7	18.77	24.29	9.88	16.38	10.38	16.45	16.02
25	44.3	17.44	18.06	16.17	14.33	14.59	16.70	16.21
26	63.9	15.05	24.36	11.90	15.88	11.30	19.30	16.30
27	69.0	17.68	29.84	25.28	23.13	13.63	25.55	22.52
28	77.8 max.	15.15	16.64	7.64	11.77	10.66	12.07	12.32
29	65.0	15.12	14.47	9.32	14.86	9.82	12.05	12.61
1930	35.7	12.40	14.49	12.73	13.54	14.64	13.16	13.49
31	21.2	20.04	11.84	9.96	11.87	7.28	10.72	11.95
32	11.1	15.48	21.03	16.58	19.04	13.91	18.34	17.40
33	5.7 min.	21.78	12.97	14.11	17.89	15.83	19.21	16.96
34	8.7	19.16	14.03	13.05	11.37	12.84	11.55	13.67
35	36.1	23.79	17.81	13.56	17.34	13.28	23.06	18.14
36	79.8	16.53	9.77	9.63	11.80	10.24	16.25	12.37
37	114.4 MAX.	19.34	20.18	9.80	8.31	12.47	10.54	13.44
38	109.6	19.81	16.29	17.49	14.31	15.83	18.72	17.07
Sunspot-precipitation coefficient of correlation (r)		−0.4222**	−0.2780*	−0.1260	−0.1779	−0.3891**	−0.2199	−0.2017

** *1% level of significance.*
* *5% level of significance.*

water-equivalent of snow was calculated on the basis of ten inches of snowfall equalling one inch of rainfall.

The coefficient of correlation *(r)* for each station is given at the bottom of the table. The correlation is negative for all stations (a terrene response, according to DeLury's classification). The values of *r* obtained for Edmonton and Battleford are significant to the 1% level, while that for Calgary reaches the 5% level. These significant values, together with the unanimity of agreement of all stations with respect to the negative correlation, are believed to establish the fact that sunspot periodicity exerts a measurable influence on precipitation in the region.

It is possible that special significance may be attached to the fact that the influence of the sunspot cycle is somewhat greater at the most northerly of the stations, Edmonton and Battleford. The fact that the sunspot influence at Calgary is greater than at other southern stations may be due to its position in the foothills.

These geographical distinctions are considered admissible under the hypothesis that factors such as prevailing air currents, varying from region to region, would differ from region to region in their effectiveness in overcoming the sunspot influence. The sunspot factor must be considered as an all-pervading agency which, at a given time, affords to all regions the same degree

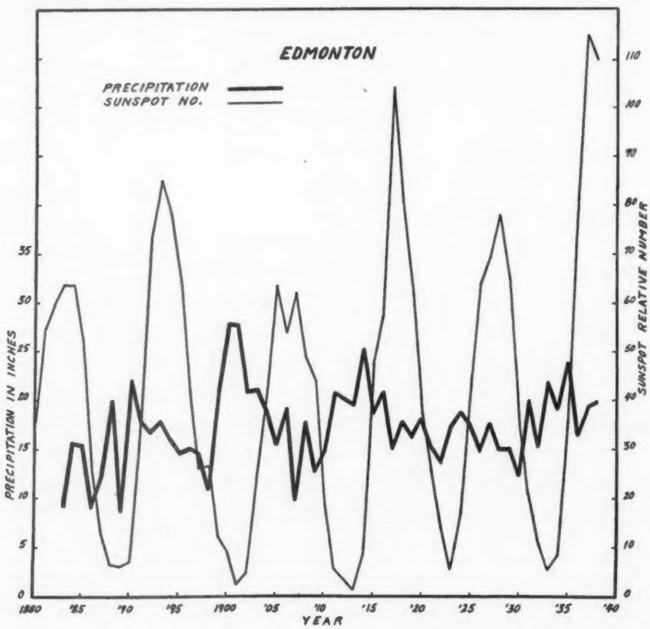

FIG. 2. *Comparison of total annual precipitation at Edmonton with corresponding yearly means for sunspot relative numbers.*

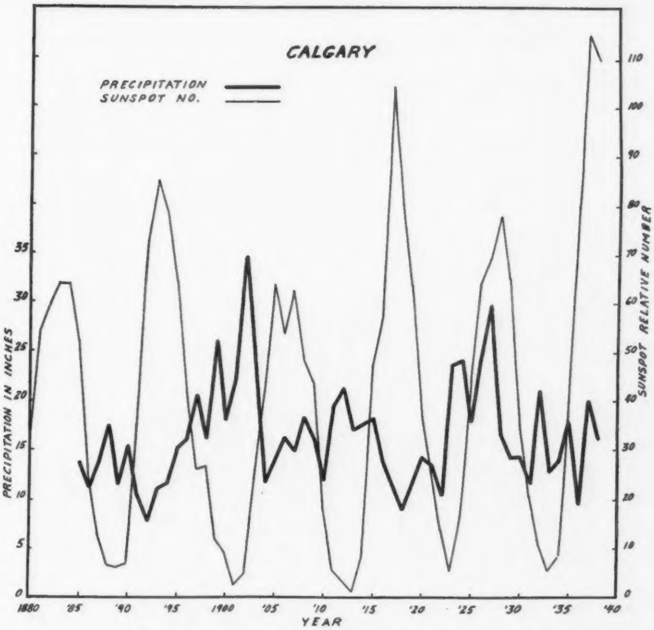

FIG. 3. *Comparison of total annual precipitation at Calgary with corresponding yearly means for sunspot relative numbers.*

of potential influence. The actual influence in a given region is determined by the degree to which the potential influence is affected by the complex of other meteorological factors operating in that particular region.

Graphical representations of the association between sunspot periodicity on the one hand, and precipitation at Edmonton, Calgary, and Battleford on the other, are given in Figs. 2, 3, and 4, respectively. The general tendency for the precipitation curve to rise at sunspot minima and to drop at sunspot maxima (hence minus sign of r values) is reasonably apparent in all graphs. There are, however, a number of breaks in this relation, the most notable being the unusually high precipitation occurring at Calgary in 1927, which was within one year of sunspot maximum. These breaks may be explained by the hypothesis given in the preceding paragraph.

The Calgary graph (Fig. 3) illustrates what may be an important point in connection with the double cycle. It may be significant to note that there have been three periods of excessive drought which centre upon the years 1892, 1918, and 1936, and that each of these drought centres is within one year of a sunspot major maximum. This relation, however, does not hold generally for the other districts under study.

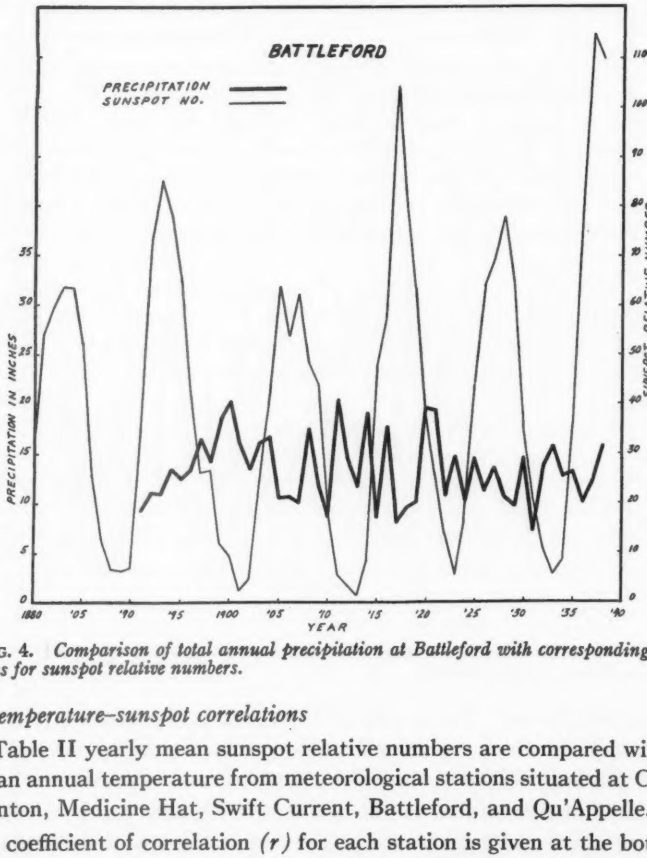

FIG. 4. *Comparison of total annual precipitation at Battleford with corresponding yearly means for sunspot relative numbers.*

(c) Temperature–sunspot correlations

In Table II yearly mean sunspot relative numbers are compared with data on mean annual temperature from meteorological stations situated at Calgary, Edmonton, Medicine Hat, Swift Current, Battleford, and Qu'Appelle.

The coefficient of correlation *(r)* for each station is given at the bottom of the table. In no case is the value of *r* significant. Some significance, however, may be attached to the fact that, as in sunspot-precipitation correlations, all values of *r* are negative (terrene response). Irrespective of the significance of individual values of *r*, as tested by the probable errors based on the populations of individual groups of data, the fact that six consecutive values have shown the same directional relation between the variables may be considered to indicate a possibility that true minus correlation exists, but that the degree of association is not sufficient to be definitely established on the basis of the relatively small period of time for which data are available.

It is concluded, therefore, that while the available data are insufficient to establish a mathematically significant correlation between variations in sunspot number and temperature, there are, nevertheless indications that some association between these variables does exist.

TABLE II

YEARLY MEAN SUNSPOT RELATIVE NUMBERS COMPARED WITH TEMPERATURE DATA FROM SIX POINTS IN ALBERTA AND SASKATCHEWAN

Year	Sunspot relative number	Mean annual temperature in °F. at						Mean of all points
		Edmonton	Calgary	Medicine Hat	Swift Current	Battleford	Qu'Appelle	
1883	63.7 max.	32.9	—	—	—	—	—	—
84	63.5	33.6	35.4	40.1	—	—	30.6	—
85	52.2	36.6	40.0	41.9	—	—	33.2	—
86	25.4	34.5	37.9	41.3	38.4	—	33.8	—
87	13.1	31.5	34.3	37.0	34.5	—	30.9	—
88	6.8	34.7	36.7	39.4	36.0	—	32.4	—
89	6.3 min.	40.9	40.5	43.1	40.2	—	37.9	—
1890	7.1	36.6	37.0	40.1	37.5	—	34.0	—
91	35.6	38.4	38.8	42.0	38.8	32.9	34.8	37.6
92	73.0	36.3	38.1	40.9	37.6	32.6	33.2	36.5
93	84.9 MAX.	34.6	35.3	38.0	35.2	30.3	31.0	34.1
94	78.0	36.8	38.8	43.0	39.7	34.5	36.1	38.2
95	64.0	37.0	37.2	40.0	36.8	33.6	33.4	36.3
96	41.8	34.8	35.9	40.0	37.7	32.5	33.0	35.7
97	26.2	36.7	36.9	40.0	38.0	34.0	34.0	36.6
98	26.7	38.2	37.8	40.9	37.9	34.0	34.2	37.2
99	12.1	34.6	34.7	39.0	35.5	32.4	32.1	34.7
1900	9.5	37.8	38.6	43.6	40.8	34.9	36.4	38.7
01	2.7 min.	39.0	39.2	43.3	40.2	36.5	36.3	39.1
02	5.0	36.9	36.9	41.5	38.4	34.3	35.7	37.3
03	24.4	37.6	37.6	41.9	38.1	33.9	35.0	37.4
04	42.0	36.2	36.9	42.0	37.5	33.4	34.0	36.7
05	63.5 max.	39.4	39.0	43.7	40.1	37.1	37.0	39.4
06	53.8	40.1	39.3	44.0	40.3	36.8	37.2	39.6
07	62.0	35.2	36.7	40.7	35.8	32.2	32.9	35.6
08	48.5	Incomplete	40.7	44.7	39.7	35.2	36.2	—
09	43.9	33.8	36.0	41.1	36.0	32.2	32.9	35.3
1910	18.6	38.4	40.4	Incomplete	41.5	36.6	36.4	—
11	5.7	36.0	35.7	Incomplete	35.9	32.6	32.5	—
12	3.8	39.5	39.4	43.0	38.1	36.6	34.2	38.0
13	1.4 min.	37.8	40.1	43.7	39.0	36.8	35.2	38.8
14	9.6	36.7	40.5	44.3	39.8	37.5	36.5	39.2
15	47.4	39.2	41.8	45.0	40.4	38.6	37.6	40.4
16	57.1	34.8	37.4	39.5	34.9	33.3	32.3	35.4
17	103.9 MAX.	34.6	37.9	41.0	36.1	33.6	33.0	36.0
18	80.6	37.9	41.5	44.1	40.4	36.9	37.4	39.7
19	63.6	35.5	39.5	43.0	38.9	35.5	35.2	37.9
1920	37.6	35.9	38.9	43.2	39.9	36.0	36.4	38.4
21	26.1	37.1	39.7	44.4	40.9	36.7	37.7	39.4
22	14.2	36.7	39.0	42.6	38.3	36.8	36.0	38.2
23	5.8 min.	38.7	40.9	44.7	34.4	38.0	35.0	38.6
24	16.7	36.5	38.6	43.1	38.1	36.1	35.1	37.9
25	44.3	35.9	39.5	43.1	39.4	35.6	36.0	38.3
26	63.9	37.7	41.0	44.8	40.0	36.8	35.7	39.3
27	69.0	33.1	35.7	39.9	37.0	32.7	33.0	35.2
28	77.8 max.	39.0	41.4	44.6	41.8	38.1	37.4	40.4
29	65.0	36.3	38.5	41.7	38.0	34.9	33.8	37.2
1930	35.7	38.7	40.1	44.9	41.1	37.7	36.6	39.9
31	21.2	40.0	41.7	45.5	44.3	39.5	40.9	42.0
32	11.1	36.0	37.6	40.9	38.9	33.3	35.2	37.0
33	5.7 min.	35.2	37.4	41.8	42.8	33.5	35.6	37.7
34	8.7	38.4	41.8	44.9	42.6	37.2	38.4	40.6
35	36.1	37.1	37.1	40.0	37.8	32.2	34.0	36.4
36	79.8	36.1	37.4	40.2	37.5	33.0	33.5	36.3
37	114.4 MAX.	36.9	36.9	40.4	38.3	32.5	35.2	36.7
38	109.6	38.5	40.2	43.0	41.0	36.6	37.7	39.5
Sunspot-temperature coefficient of correlation *(r)*		−0.1786	−0.0179	−0.0829	−0.0618	−0.2323	−0.0987	−0.1946

(d) Crop yield–sunspot correlations

The demonstration of a mathematically significant causal relation between sunspots and annual precipitation coupled with the determining influence of precipitation (particularly during the growing season) on yield, leads, as a matter of course, to the testing of possible correlations between sunspots and crop yield.

In Table III yearly mean sunspot relative numbers are compared with data on average yields per acre of wheat, oats, and barley in Alberta and Saskatchewan, respectively.

In the case of wheat yield data from both Alberta and Saskatchewan, an attempt was made to include only data from the strictly semi-arid regions (where precipitation is a highly determining factor in yield). In Table III, therefore, the following conditions apply to wheat yield data:

The figures for Alberta represent the total provincial production for the years 1898–1920, inclusive, while for the years 1921–1938, inclusive, they represent only the production for crop districts 1 to 7 inclusive.

The figures for Saskatchewan represent total provincial production for the years 1898–1903, inclusive; while for the years 1904–1938, inclusive, they cover the region represented in 1904–05 by crop districts 1–6; in 1906–07 by crop districts 1–6, 8, 10–13, and 17–20; in 1908–15 by crop districts 1–3, 5, and 6; and in 1916–38 by crop districts 1–4, 6, and 7. [For details on crop districts see Seventh Census of Canada, 1931, vol. VIII (Agriculture)].

Wheat data for Alberta involve only spring wheat, while for Saskatchewan spring and winter wheat data are combined as one figure. The proportion of winter wheat would, however, be negligible.

Data for oats and barley in both provinces represent total provincial production.

The coefficient of correlation (r) for each crop in each province is given at the bottom of Table III. In no case is the value of r significant; but in seven out of eight cases the value is a minus one, and the exceptional plus value is of a far lower order than the minus values generally. This is taken to indicate that the influence of sunspot periodicity on precipitation may carry over in a degree to the secondary result, crop yield.

General Discussion

It is concluded in general that the present study has served to demonstrate that sunspot periodicity has a mathematically measurable influence on precipitation, and possibly also on temperature and crop yields, in certain semi-arid regions of Alberta and Saskatchewan. The points that remain to be discussed are first, the relative importance of the sunspot cycle as one of the factors determining weather, and second, the degree to which the sunspot factor may be used in long-range weather forecasting.

The sunspot-precipitation correlations may be considered as a reasonably conclusive proof of the fact that sunspot periodicity is one of the factors

TABLE III

YEARLY MEAN SUNSPOT RELATIVE NUMBERS COMPARED WITH AVERAGE ANNUAL YIELDS OF WHEAT, OATS, AND BARLEY IN ALBERTA AND SASKATCHEWAN

Year	Sunspot relative number	Mean yield in bushels per acre					
		Wheat		Oats		Barley	
		Alberta	Sask.	Alberta	Sask.	Alberta	Sask.
1898	26.7	25.3	17.3	44.5	24.0	32.0	21.8
99	12.1	23.7	18.4	42.2	30.1	26.8	20.9
1900	9.5	19.2	9.0	33.8	16.6	25.4	18.1
01	2.7 min.	24.6	25.4	40.7	44.7	32.8	31.4
02	5.0	18.9	22.5	31.7	30.9	21.3	20.9
03	24.4	18.7	19.4	32.0	32.7	25.5	24.9
04	42.0	16.6	17.6	31.0	31.0	26.1	24.2
05	63.5 max.	21.5	20.4	39.2	42.7	27.4	27.1
06	53.8	23.1	21.1	39.1	37.4	29.3	24.5
07	62.0	18.3	13.4	30.1	29.0	19.8	17.9
08	48.5	18.8	13.7	36.9	27.2	25.0	17.2
09	43.9	19.0	21.6	35.8	47.1	30.7	32.1
1910	18.6	12.9	15.0	24.7	30.4	20.8	24.5
11	5.7	20.8	18.3	41.2	45.0	29.4	28.0
12	3.8	18.2	20.0	38.2	44.4	27.9	31.1
13	1.4 min.	19.5	19.2	36.1	41.7	25.9	30.2
14	9.6	15.3	12.1	30.2	23.8	23.0	17.9
15	47.4	31.1	25.1	56.7	45.9	34.1	33.2
16	57.1	26.6	13.8	43.8	39.1	28.6	26.5
17	103.9 MAX.	19.0	13.7	32.1	27.2	22.6	21.0
18	80.6	7.7	9.0	22.8	21 5	16.5	17.0
19	63.6	12.0	7.7	28.2	23.1	25.5	18.2
1920	37.6	20.5	10.4	37.3	27.7	26.5	20.2
21	26.1	11.0	12.8	30.0	32.7	22.3	25.9
22	14.2	11.1	20.1	21.5	35.2	14.9	29.0
23	5.8 min.	27.5	20.8	50.0	44.5	38.5	30.0
24	16.7	9.1	10.4	30.0	19.7	25.0	18.2
25	44.3	17.0	17.6	31.0	34.5	25.0	25.4
26	63.9	17.9	15.7	30.0	28.1	22.0	25.1
27	69.0	27.8	19.2	45.0	32.3	30.0	29.3
28	77.8 max.	26.2	23.9	37.7	35.8	29.1	27.3
29	65.0	10.9	9.9	21.9	16.2	17.8	13.8
1930	35.7	17.1	12.2	36.0	27.7	25.4	20.1
31	21.2	13.3	6.1	36.7	15.8	29.3	10.4
32	11.1	19.3	11.9	37.5	24.6	28.1	17.6
33	5.7 min.	9.6	6.0	25.3	16.5	20.3	14.3
34	8.7	12.0	5.7	26.7	13.9	20.1	11.4
35	36.1	12.5	10.1	26.5	26.7	17.8	20.2
36	79.8	5.6	6.5	19.7	14.0	17.0	12.8
37	114.4 MAX.	7.7	0.9	27.6	5.1	22.2	4.7
38	109.6	17.5	8.7	35.0	21.6	26.0	16.6
Sunspot-yield coefficient of correlation (r)	1898–1920	−0.1555	—	−0.0487	−0.2773	−0.1876	−0.2778
	1898–1903	—	−0.2733				
	1921–1938	+0.0165	—				
	1904–1938	—	−0.1943				

determining the amount of precipitation falling in the region under study. Yet the data show that the influence of the factor is often completely nullified and that the correlation in certain regions falls below mathematical significance. The breakdown of the sunspot influence occurs irregularly at any stage of the cycle and may occur at a given time in one region without being in evidence in a similar neighbouring region. These conditions appear to be characteristic of the data and may, therefore, be of some use in formulating a hypothesis on the sunspot cycle as an effective factor in weather determination.

We have some basis, therefore, for stating a hypothesis that presumes the sunspot factor to be a radial agency which pervades uniformly the upper terrestrial atmosphere, but which does not uniformly influence weather components (precipitation, temperature, etc.), since its effectiveness in the lower atmosphere is affected in various ways and to different degrees by a variable complex of meteorological and physical factors. Many of these factors, and we may here include the effective sunspot influence, tend to fluctuate independently in their effectiveness as weather-determining agents. Thus, at different times, different combinations of factors determine the weather. Assuming that certain factors tend to neutralize the effect of the sunspot factor while certain others are indifferent or beneficial, it follows that at different times, as different factors rise and fall in effectiveness, the sunspot factor will fluctuate in power from a nonentity to its fullest expression as a weather-determining agent.

This may be acceptable as a plausible explanation of the irregular breakdown of the sunspot influence on precipitation, but it does not give an answer to the question why, in the region being studied, the data from the two most northerly stations, Edmonton and Battleford, should give considerably higher correlations, in the case of both precipitation and temperature, than do the data from the four southern stations. One might reasonably suppose that the two northern stations are subjected to some relatively stable factor, such as a prevailing air current, which year after year tends to provide conditions conducive to increased effectiveness of the sunspot factor. This point indicates that, in studying sunspot-weather relations, it may be important to treat the data from each station separately.

In the light of the above discussion and within the limits of the present study, what may be said regarding the relative importance of the sunspot cycle among weather-determining factors? It may be said that, in the region under study, sunspot periodicity probably bears some causal relation to precipitation and perhaps also to temperature; but the influence of other agencies tends to suppress and obscure its effect to a point where it becomes in general only a minor contributing factor.

What, then, may be said for the sunspot cycle as a basis of long-range weather forecasting for the region under study? In the first place, long-range weather prediction as a general field is not yet acceptable as a workable science. Before it can be so accepted, we must formulate and prove a theory

of extra-seasonal climatic sequence. Such a theory is not in immediate prospect: first, many meteorological and physical factors, many solar and terrestrial cycles, the overtones of the sunspot cycle itself, must be recognized, disentangled, studied separately, and mastered. What we know at present of the sunspot cycle and its influence on weather is but one step, and a small one, toward an ultimate theory of long-range climatic sequence—and what we know must not be used for more than it is worth.

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CONTRIBUTIONS TO A STUDY OF THE FUNGUS FLORA OF NOVA SCOTIA

IV*. ADDITIONAL BASIDIOMYCETES[1]

By L. E. Wehmeyer[2]

Introduction

In previous papers, collections of fungi from Nova Scotia belonging to the Heterobasidiomycetes, Dacryomycetaceae, and Clavariaceae (28), resupinate Hydnaceae (29), and Agaricaceae and Boletaceae (26) have been listed and discussed. The remaining Basidiomycetes are here considered. The large majority of these collections were made during the summer of 1931, with a moderately heavy rainfall, and the summer of 1933, with a very slight precipitation. These collections represent probably only a fraction of the species obtainable over a longer period of time. In 1931, the species of the genus Hydnellum were particularly abundant in the more open, moist, conifer forests, and this opportunity was taken to obtain full field notes on the fresh plants in all stages of development.

As indicated in a previous paper (28), all localities cited are in Colchester County unless otherwise designated. The numbers after each collection are the field collection numbers. Species not previously reported from the Province are indicated by an asterisk (*). Colour names given in quotation are those of Ridgeway's *Color Standards* and *Color Nomenclature.*

BASIDIOMYCETES

Exobasidiaeceae

***Exobasidium Vaccinii** (Fck.) Wor. On *Vaccinium* sp., Victoria Park, Truro, June 26, 1933 (1540).

Thelephoraceae

Most of the writer's collections of the Thelephoraceae were critically examined by M. A. Donk, who made many of the determinations, as indicated. Most of the species of Hypochnus (Tomentella) were determined by V. Litschauer. For the sake of consistency, Burt's generic separations are adhered to in the following list. Where the determiner's nomenclature differs from this it is indicated in parenthesis.

***Hypochnus cervinus** Burt. On *Poria* sp., Upper Brookside, Aug. 24, 1931, det. V. Litschauer (*Tomentella cervina* (Burt) Bourd. & Galz.) (1404). This determination seems somewhat doubtful to the writer, inasmuch as the colour of this specimen is "vinaceous-drab" to "purple-drab" rather than "fawn colour" as given by Burt for *H. cervinus*. It

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* *The preceding papers of this series were published in the Papers of the Michigan Academy of Science, Arts and Letters (see References 26, 28, and 29).*

is similar to *H. subvinosus* Burt, except that it is not 250–300 μ thick and does not have coloured hyphae near the substratum. This specimen forms a very thin floccose-pruinose coat on the pores of the host. There is scarcely any trama, but the margin thins out to a pale arachnoid subiculum. Clamp connections are doubtfully present. The spores are subglobose to angular, rather coarsely echinulate, hyaline at first, becoming yellow-brown, and are 4–6 $\times$ 4–5.5 μ.

* — **fumosus** Fr. On decayed wood, Salmon River region, July 3, 1931 (368); Folleigh Lake, July 20, 1931 (1100); Upper Brookside, July 24, 1931, *fide* M. A. Donk (*Corticium fumosum* Fr.) (1146); Mt. Thom, Aug. 10, 1931 (1252).

* — **fuscus** Fr. On Betula, Victoria Park, Truro, Aug. 30, 1933, det. V. Litschauer (*Tomentella fusca* (Fr.) Schroet.) (1643).

* — **olivascens** (Berk. & Curt.) Burt. On decayed wood, Upper Brookside, Aug. 24, 1931, *fide* V. Litschauer (*Tomentella olivascens* (Berk. & Curt.) Bourd. & Galz.) (1402).

* — **subfuscus** Karst. On Fagus, Upper Brookside, Aug. 11, 1931, det. V. Litschauer (*Tomentella subfusca* (Karst.) v. Höhn. & Litsch.) (1271).

* — ***testaceus*** (Bourd. & Galz.) comb. nov. On *Polyporus versicolor*, Upper Brookside, Aug. 24, 1931, det. V. Litschauer (*Tomentella testacea* Bourd. & Galz.) (1398). The spores (3–5.5 $\times$ 5–6.5 μ) and the basidia (8–12 $\times$ 2.5—3.5 μ) of this collection are definitely smaller than those given by Bourdot and Galzin for *T. testacea* (6, p. 493). A very fine, floccose-pulverulent, brick-red growth is formed on the pore surface. There is a sparse basal mycelium of dark-brown hyphae, which have clamp connections and are 2.5–6.5 μ in diameter. The hymenium is of compacted hyaline upright basidia. I have seen on description which fits this exactly.

* — **umbrinus** (Fr.) Quél. On beech log, Upper Brookside, Aug. 11, 1931 (1269); on Poria, Upper Brookside, Aug. 24, 1931, det. V. Litschauer (*Tomentella umbrina* (Fr.) Litsch.) (1401). This species is deep blue-black to indigo when fresh, becoming greyish- to brown-cinereous and pruinose on drying. It forms a separable velvety-cottony mat 300–600 μ thick. There is a basal layer of large, loose, dark-brown hyphae, 3–5.5 μ in diameter, without clamps, and an upper layer of lighter coloured, narrower, more closely branched and more compact hyphae, which may have a greenish- to bluish-black tinge and which bear the basidia, which are about 50 $\times$ 8–10 μ. In the subhymenial and hymenial layers there are numerous, clavate, gloeocystidial organs, which are transparent and indigo to blue-black in colour. The spores are globose to subglobose, dark brown, coarsely tuberculate-echinulate and 6.5–10 $\times$ 6–8 μ.

* **Corticium bombycinum** (Sommerf.) Bres. On *Salix* sp., Victoria Park, July 23, 1931, *fide* M. A. Donk (1121).

* — **botryosum** Bres. On conifer bark, Upper Brookside, July 8, 1931, det. M. A. Donk (*Botryobasidium botryosum* (Bres.) Donk) (428). Burt (10, p. 295) gives this as a synonym of *C. vagum*. The spores of this plant (5–8.3 $\times$ 3.3–5 μ, amygdaloid) are smaller than those described by Burt, but this collection fits very well Overholts' (22, p. 509) conception of *C. vagum*. There seems to be little difference between this species and *C. coronatum*, according to Bourdot and Galzin, and our collection is more or less intermediate, but the substrate is similar to that given for *C. botryosum* (limbs of Pine).

* — **calceum** var. **glebulosum** Fr. On fir wood, Salmon River region, Aug. 19, 1933, det. M. A. Donk (1634). In his remarks, Donk states, "Note small cystidia. The specimen agrees with one in the Herb. Fries at Uppsala, as *C. calceum* var. *glebulosum*, from Femsjo, and indicated as the type of the species (*calceum*). Burt, however, had no clear idea of this species. He confused at least three different species: 1—the real *C. calceum* Fr. em. Burt; 2—*C. Romellii* Litsch. in herb.; and 3—*C. pseudo-calceum* Donk in herb., Litsch. in litt. The real *calceum* is rare in Europe, beside the type I know of only one more, from Sweden, collected by Nannfeldt. It seems, however, to be more common in the United States (Burt, Brown, etc.)."

These "cystidia" are tapered toward the apex, or somewhat swollen at the base, and have a more or less swollen globose apex which is often encrusted with crystals that are mostly soluble in potassium hydroxide. They project 15–35 μ beyond the hymenium, and the swollen apex is 3–5 μ in diameter (Fig. 1, *c* and *d*).

— **investiens** (Schw.) Bres. (?). On *Rhododendron canadense*, Upper Brookside, July 8, 1931 (433). This species has been transferred to the genera Vararia Karst. and Asterostromella Höhn. & Litsch. by many writers on account of the dichotomously branched, coloured, spinelike, wide-angled branching hyphae or "dichophysen". Donk, upon examination of these plants, considered that it might represent a new species of Vararia, but was unable to find spores. Upon further examination, the writer has been able to locate a few basidia and spores (Fig. 1, *a* and *b*). These spores agree very well with those of *C. investiens*, and the other differences, such as the somewhat lighter and more yellowish coloration, somewhat thinner and less tuberculate fruiting layers, and slightly paler hyphae are largely differences of degree. It seems doubtful if this is more than a variety of *C. investiens.*

The plants are "cartridge buff" to "chamois" when fresh, form elongated effuse patches, and become somewhat paler on drying. The surface is somewhat mealy and friable in character; the margin is sharp and undifferentiated. Hyphae 1.5–2.5 μ in diameter, with wide angled branching and tapering to a point at the ultimate tips. Fruit bodies 400–600 μ thick. Basidia (Fig. 1, *a*) 9–10 $\times$ 3–5 μ, four-spored, scattered irregularly over the surface. Spores ellipsoid to fusoid or tapered towards one end, hyaline, 5–9 $\times$ 2–3.5 μ (Fig, 1, *b*).

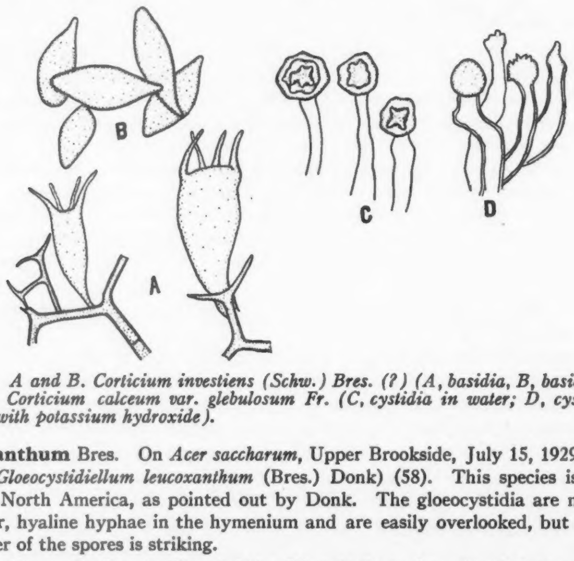

FIG. 1. *A and B. Corticium investiens (Schw.) Bres. (?) (A, basidia, B, basidiospores). C and D. Corticium calceum var. glebulosum Fr. (C, cystidia in water; D, cystidia after treatment with potassium hydroxide).*

*— **leucoxanthum** Bres. On *Acer saccharum*, Upper Brookside, July 15, 1929, det. M. A. Donk (*Gloeocystidiellum leucoxanthum* (Bres.) Donk) (58). This species is apparently new to North America, as pointed out by Donk. The gloeocystidia are merely large, irregular, hyaline hyphae in the hymenium and are easily overlooked, but the amyloid character of the spores is striking.

*— **lividum** Pers. On Betula (?) and Abies, Victoria Park, Aug. 30, 1933, det. M. A. Donk (1642 & 1642a). Waxy-fleshy when fresh and with the margin bluish-glaucous or "citron yellow" to "strontian yellow", often with yellowish strigose or cottony hyphae. Hymenium "vinaceous-fawn", "wood brown", "fawn" or "vinaceous-tawny". When dry, the surface is often thickly covered with small sulphur-yellow granules composed of crystals that break through the surface. Spores ellipsoid, more or less curved or flattened, 3.5 $\times$ 1.5–2 μ.

*— **ochraceum** Fr. On decorticated conifer, Mt. Thom, Aug. 15, 1931, det. M. A. Donk (*Gloeocystidium ochraceum* (Fr.) Litsch.) (1338). Considered by Donk as "a very rare species". The gloeocystidia are scarcely distinguishable. They are given by Bourdot and Galzin (6, p. 266) as "non émergentes". There are emergent cystidial elements in this material, however, which are cylindric to conic, 2–4 μ in diameter and projecting 8–16 μ beyond the hymenial surface. These fruit bodies are stratified, and the cystidia may be the early outgrowth of hyphae that begin the formation of a new layer.

***Peniophora aurantiaca** Bres. On Alnus, Victoria Park, Sept. 7, 1929 (285); Salmon River region, Aug. 25, 1931, *fide* M. A. Donk (1409). Neither Rea nor Bourdot and Galzin mention gloeocystidia for this species. The hymenium is made up largely of swollen hyphal elements, 20–50 × 6–10 μ, which are filled with a granular protoplasm when young. These are as obviously gloeocystidia as those that are found in many species of Gloeocystidium; and it seems probable that many so-called gloeocystidia are merely the young sterile elements of the hymenium, which probably grade off into the differentiated forms in other species.

*— **carnosa** Burt. On *Abies balsamea*, Salmon River region, July 3, 1931 (369); on Fagus, Upper Brookside, July 17, 1931 (1072); on decayed wood, Killag Mines, Halifax Co., July 30, 1931 (1188); Salmon River region, Aug. 19, 1933, *fide* M. A. Donk (1651). Of the many closely similar yellow species of Peniophora, these collections fit *P. carnosa* best. Although not mentioned in Burt's description, the greenish-yellow coloration of the basal hyphae is often due to a granular encrustation. This colour is slowly turned to green and then bleached by 7% potassium hydroxide.

*— **cinerea** (Fr.) Cke. On *Betula alba*, Upper Brookside, July 8, 1931, det. M. A. Donk (430).

*— **cremea** Bres. On *Polyporus betulina*, Upper Brookside, June 27, 1931, det. M. A. Donk (301). This fits *P. cremea* very well except that the spores are somewhat smaller (4.3–6 × 2.5 μ; only a few seen) and that the cystidia protrude only 20–30 μ. Donk considers it either *P. cremea* or *P. parilis* Bourd. (in litt.) but wishes to make further comparisons.

*— **hydnoides** Cke. & Mass. On Fagus, Upper Brookside, July 7, 1931, *fide* M. A. Donk (421). Donk (in litt.) states that all material he has seen from America "differs from the type by the somewhat shorter, broader, and more conical cystidia with thicker wall (in the average), and by the arrangement of the cystidia: being sessile on one or a few axial cystidia-like hyphae in the teeth, more or less enclosed by the trama of the teeth." This he recognizes as a var. *americana*.

This species is placed in the genus Odontia by many writers as *O. hydnoides* (Cke. & Mass.) v. Höhn. This collection shows only extremely minute teeth and is therefore retained in Peniophora. Collections have been made in Michigan that are identical in every respect, except that the teeth are definite and up to 0.5 mm. in length. When fresh, this species has a characteristic bluish-grey translucent appearance. As the teeth enlarge and mature they turn cream colour upon drying, but the margin or context, if exposed, may retain the bluish-grey colour. Most descriptions give the colour as whitish or cream colour.

*— **incarnata** (Fr.) Cke. On Acer, Economy Lake, June 16, 1926, det. M. A. Donk (93). The writer agrees with Donk in his statement (in litt.) that "the hyphae are in some parts of the fructification slightly encrusted. For me (and Bourdot too), *P. affinis* Burt is a synonym of this species". (This collection was first determined as *P. affinis*, by the writer.)

*— **laevis** (Fr.) Burt. On Fagus, Upper Brookside, Sept. 1931, det. M. A. Donk (1514).

*— **pallidula** Bres. On conifer wood, Victoria Park, Truro, Aug. 30, 1933, det. M. A. Donk (1645). This species, which forms a greyish to olive-grey, sparse, floccose growth on decorticated wood, has characteristic cystidia consisting of upright, irregularly cylindric, hyaline hyphae, 3.5 μ in diameter, which have an apical, and often several axial, spherical, light-brown, resinous masses, which are soluble in iodine-chloral-hydrate solution or Amann's mounting medium (lactic acid). The spores were somewhat smaller (3.5 ×

2–2.5 μ) than given by Bourdot and Galzin, and the cystidia were not noticeably nodose, except for the resinous masses.

* — **setigera** (Fr.) Bres. On Abies, Victoria Park, Truro, Aug. 8, 1929 (215); on *Betula alba*, Upper Brookside, June 29, 1931 (325); on Alnus, Upper Brookside, June 27, 1931, det. M. A. Donk (501).

* — **velutina** (Fr.) Cke. On Fagus, Upper Brookside, July 11, 1931 (493): July 28, 1931, det. M. A. Donk (1176). Donk, in his notes, says "*P. velutina*, the form which Burt calls *P. coccineo-fulva* (Schw.) Burt. I do not believe this to be a species different from *velutina*. Bourdot is of the same opinion, according to specimens from his herbarium or named by him". This material is also very similar to that named by Donk as *P. laevis*. That collection (No. 1514) differs only in the somewhat paler colours of the dry hymenium. This paler colour is the distinction used by Burt to separate *P. velutina* and *P. coccineo-fulva*. Burt states (9, p. 257) that *P. laevis* differs from *P. coccineo-fulva* in the narrower basal hyphae. Bourdot (6, p. 307) gives the basal hyphae of *P. laevis* as 7–8 μ and those of *P. velutina* as 8–10 μ. In all these collections the hyphae vary from 4 to 9 μ. There are a number of other species in this same group that are difficult to distinguish, and it is apparent that entirely too many species have been erected with no regard to already described ones.

***Aleurodiscus amorphus** (Fr.) Rabenh. On *Abies balsamea*, Upper Brookside, June 29, 1931 and July 7, 1931 (331 & 331b); Middle River, Victoria Co., Cape Breton Island, Aug. 5, 1931 (331a). Common on dead or dying standing fir, the pinkish-orange fruiting bodies resembling a Discomycete.

* — **scutellatus** Litsch.† On bark of spruce, Upper Brookside, July 26, 1929 (77); on standing conifer, Salmon River region, July 14, 1931, det. M. A. Donk & V. Litschauer (77a). As pointed out by Donk, this species has been reported only from two localities in Europe (Northern Alps and Hohe Tatra) and from the Chinese province of Yunnan. It is new to North America. These plants are small, 1–4 mm. in diameter, more or less circular and with upturned margins, giving them a cup-shaped appearance. The outer surface is light sand-colour, and the hymenium greyish-pulverulent. The fruit body is 300–400 μ thick and stratose. The hymenium contains numerous large basidia, 10–13 μ in diameter and up to 60 μ in length, and smaller sterile hyphae, 3–4.5 μ in diameter and sometimes nodose-constricted at the apex. Spores large, hyaline, ovoid to subglobose, 12–15 × 10–13 μ.

* **Stereum abietinum** Fr. On fir log, Salmon River region, Aug. 19, 1933, det. M. A. Donk (1635). This species has a superficial resemblance to *S. sanguineolentum* but is almost entirely resupinate and contains large cylindric, thick-walled, dark brown, encrusted cystidia, 5–9 μ in diameter, which project up to 70 μ beyond the hymenium.

— **fasciatum** Schw. On hardwoods, Folleigh Lake, Sept. 23, 1927 (33 & 34), leg. A. R. Prince (6036 & 6153): Salmon River region, July 15, 1931 (1048).

* — **Murrayi** (Berk. & Curt.) Burt. On Acer, Mt. Thom, Aug. 15, 1931, *fide* M. A. Donk; on Betula, Salmon River region, July 14, 1931 (1021); Folleigh Lake, July 20, 1931 (1108); Mt. Thom, Aug. 15, 1931, *fide* M. A. Donk (1319). Burt (8, p. 131) does not mention gloeocystidia for this species, but Bourdot and Galzin (6, p. 381) point out that they are always present in American material. These collections show such clavate to elongate gloeocystidia. They are 25–40 × 6.5–9 μ, and are filled with a yellowish oily substance when fresh. All transitions between these gloeocystidia and the vescicular bodies of the lower tramal layers are found; and it is apparent that the gloeocystidia become swollen and lose their oily content, and so give rise to the vescicular bodies.

— **purpureum** Fr. On *Salix* sp., Bible Hill, Truro, Nov. 21, 1931, coll. A. R. Prince, det. M. A. Donk (1657).

†*This species has been shown to be a synonym of A. subcruentatus (Berk. & Curt.) Burt, by M. K. Nobles (Mycologia, 29 : 387. 1937).*

* — **roseo-carneum** (Fr.) Schw. On Fagus, Upper Brookside, Oct. 24, 1926, coll. A. R. Prince, det. M. A. Donk (1516); Sept. 3, 1931, det. M. A. Donk (1516a).

* — **rufum** Fr. On *Populus* spp. Upper Brookside, July 13, 1926 and July 19, 1929 (108 & 135). Common on poplar.

— **sanguineolentum** Alb. & Schw. On *Abies balsamea*, Salmon River region, July 15, 1931 (1045); Boularderie Island, Cape Breton Co., Aug. 4, 1931, *fide* M. A. Donk; Salmon River region, Aug. 13, 1931, *fide* M. A. Donk (1300); Mt. Thom, Aug. 15, 1931 (1331). Common on dead standing fir. The coloured conducting organs are not always conspicuous in these fruit bodies and often terminate in the hymenium as hyaline, slightly pronged or encrusted, cystidia-like hyphae.

* **Hymenochaete badio-ferruginea** (Mont.) Lév. On Populus, Upper Brookside, June 29, 1931 (344); on Acer, New Glasgow Road, June 30, 1931 (345); on Abies, Earltown Road, Aug. 22, 1931 (344a). This is probably merely a form of *H. tabacina* upon upright stems, but as these collections are quite distinct, they are grouped here under this species name.

* — **corrugata** (Fr.) Lév. On Fagus, Upper Brookside, Sept. 28, 1926, coll. A. R. Prince (109); on Acer, Upper Brookside, June 29, 1931 (317); on *Betula alba*, July 1, 1931, *fide* M. A. Donk (359).

* — **corticolor** Berk. & Rav. On Fagus, Upper Brookside, July 16, 1929, *fide* M. A. Donk (50 & 51). No. 50 has the appearance of *H. corrugata*, being almost entirely effuse on the under side of limbs and cracked into small areas. It has a much lighter (bistre) colour, however, has a distinct, sharp, blackened margin, and is stratose. Donk has suggested that it is a form of *H. corticolor* (on the under side of limbs) which is undoubtedly true, although it is lighter in colour, more cracked, and effuse.

* — **spreta** Pk. On dead hardwoods, Folleigh Lake, Sept. 3, 1928, *fide* M. A. Donk (21), coll. A. R. Prince (6085); Upper Brookside, July 4, 1931 (398); July 8, 1931 (444); July 17, 1931 (1073).

— **tabacina** Lév. On *Acer spicatum*, Upper Brookside, Sept. 3, 1926 (111); Earltown Road, Aug. 22, 1931 (346a); on *Acer pennsylvanicum*, Upper Brookside, Aug. 12, 1931 (1290); on *Betula alba*, New Glasgow Road, June 30, 1931 (346); on *Taxus canadensis*, Salmon River region, July 14, 1931 (1022); on *Salix* sp. Victoria Park, Truro, July 23, 1931 (1127). Common on a large variety of hosts.

Cyphella fasciculata (Berk. & Curt.) Schw. On Alnus, Upper Brookside, July 13, 1931 (1006); Salmon River region, Aug. 25, 1931, *fide* M. A. Donk (1408).

* **Solenia anomala**† (Pers.) Fck. On Fagus, Upper Brookside, Aug. 3, 1929 (210).

* — **fasciculata**† Fr. On Betula, Upper Brookside, Aug. 3, 1929 (213); Salmon River region, Aug. 1, 1931 (1202); Aug. 13, 1921, *fide* M. A. Donk as *Henningsiomyces fasciculatus* (Pers.) Donk (1202a). This species was quite common on decaying birch trunks, forming confluent areas of fruiting bodies, usually on the surface of the bark cortex beneath the periderm.

Craterellus cornucopioides Fr. On soil under hardwoods, Upper Brookside, Aug. 26, 1931, coll. A. H. Smith (1414).

* — **infundibuliformis** Fr. Under conifers, Victoria Park, Truro, Aug. 23, 1929 (259).

* — **pistillaris** Fr. On soil in mixed woods, Upper Brookside, July 22, 1929 (214); Aug. 31, 1931, coll. A. H. Smith (214a). There has been much discussion as to whether this species is distinct from *Clavaria pistillaris*. The collections placed here are rather distinct, in the much broader and more or less depressed apex, from those (No. 1417 & 1417a) placed

† *Donk, in a letter, has pointed out that the genus name Solenia has several homonyms (Solena Lour. and Solena Willd. in the Phanerogams, Solenia Agardh. in the algae, and Solenia J. Hill in the Boletaceae). He is proposing the name Henningsiomyces O. Kze. for Solenia fasciculata and its relatives, and Cyphellopsis for S. anomala and related species. The species are listed here under Solenia merely to avoid confusion.*

under Clavaria. Young stages were followed in No. 214. The younger fruit bodies (0.5–6 cm. tall) were cylindric to obtusely conic, covered with a yellowish pruinosity, solid and white within and with a pale orange coloration towards the apex. Later, the upper portion of the club became longitudinally rugose or wrinkled and canary-yellow. The apex then became truncate-depressed to disc-shaped and reddish-orange. The oldest plants were 6–9 cm. tall and 1–2 cm. across the apex. Basidia, but no spores, had developed, the hymenium developing first on the ridges and later in the furrows of the wrinkled stipe. The plants of No. 214a were 6–8 × 2–3 cm. and turbinately expanded at the apex into a flattened pileus. The spores were 10–11 × 5–5.5 μ.

* **Thelephora anthocephala** Fr. var. **clavularis** Quél. On moss and duff, Earltown Road, Aug. 22, 1931, det. M. A. Donk (1389).

* — **multipartita** Schw. Under hardwoods, Earltown Road, Aug. 21, 1931, *fide* M. A. Donk (1382). This collection contains some specimens in which the margin is only slightly divided by shallow splits and which would agree perfectly with Burt's conception of *T. regularis*. Burt's statement (7, p. 206) that these two species are doubtfully distinct and that this should be a variety of *T. regularis* is probably correct.

* — **palmata** Fr. Under conifers, Salmon River region, July 15, 1931 (1047). Odour of radish or garlic when fresh.

— **terrestris** Fr. On soil and duff, usually under conifers, Glenholme, July 16, 1927 (23), coll. A. R. Prince (6037); Upper Brookside, July 3, 1931 (275); Salmon River region, Aug. 1, 1931 (1195); Killag Mines, Halifax Co., July 30, 1931 (1185); Salmon River region, Aug. 13, 1931, det. M. A. Donk (1294, 1295, 1301). Donk says of these collections "1195 is probably an undeveloped specimen of *T. intybacea* Fr., but I am not sure about that. European mycologists of more recent date do not recognize *terrestris* and *intybacea* sensu Fries as different species. I found in Sweden abundant specimens of the latter but am not prepared to say whether they are different or not. At this moment my impression is that the two are connected by many intermediates". No. 1195 consists of erect cylindric masses with practically no expanded pileate portions.

Hydnaceae (stipitate forms)†

Hericium coralloides (Scop.) Pers. On Fagus, Wentworth Valley, Cumberland Co., Aug. 29, 1931, coll. A. H. Smith (1427). This specimen approaches *H. caput-ursi*, having very massive main branches and a massive base, but with the branches up to 8 cm. long and much divided. The teeth are pure white, up to 15 mm. long, and clustered in fascicles on the terminal branches.

* — **laciniatum** (Leers) Banker. On Fagus, Mt. Thom, Aug. 15, 1931, coll. A. H. Smith (1310); Earltown Road, Aug. 21, 1931, coll. A. H. Smith (1310a). Base 2 cm. broad, 4 cm. high, white with a pinkish cast. Primary branches stout, 1–1.5 cm. in diameter, covered with teeth. Secondary branches short (0.5–1 cm.) with long teeth (1–3 mm.).

* **Hydnellum cyaneotinctum** (Pk.) Banker. Under conifers, Upper Brookside, July 28, 1931 (1172); Aug. 31, 1931, coll. A. H. Smith (1172b); Victoria Park, Truro, Aug. 17, 1931 (1172a); Salmon River region, Aug. 13, 1931 (1292). Occurring singly, gregarious, or sometimes confluent. Pileus 4–11 cm. in diameter, obconic, sometimes flat or convex, but usually somewhat depressed, surface usually uneven or strongly colliculose, spongy-pubescent, soft-spongy when dry, white to pinkish-cinnamon or red-brown when fresh ("light vinaceous-cinnamon" to "vinaceous-cinnamon" or "salmon-buff") with bluish areolations when young, which rapidly fade but may persist as bluish tints on stem, teeth, or context. A reddish juice is exuded when fresh, which turns the plant yellow-brown to blackish where bruised and dries a pale tan or black in these areas. Margin obtuse, sterile, often bluish. Stem central, rather elongate, rooting, 2–10 cm. long,

† *An account of the resupinate Hydnaceae has been given in a previous paper by Wehmeyer and Cejp (29).*

tapering downward, 2 cm. in diameter above, 2–6 mm. below, spongy-tough, covered with a white to bluish spongy tomentum that turns bluish where bruised, or in age, only occasionally bulbous at the base as given by Banker. Teeth cylindric, crowded, 2–3 mm. long, shorter toward the margin, decurrent, pinkish-white at first, soon with a definite, bluish, glaucous bloom ("Ontario violet"), finally becoming reddish-brown from the base upwards, black where bruised, drying a pale cinnamon or black. Context duplex, surface spongy, interior woody-fibrous, somewhat zonate, pinkish-tan with dark watery zones or bluish, sometimes greenish, areas, often bluish along the margin, drying pinkish-tan to dark brown. Spores irregularly subglobose, coarsely tuberculate, light yellowish-brown, 4–5 × 3.5–4.5 μ. Odour slightly fragrant, taste mild.

This species is quite common under conifers. Although it has the cinnamon or reddish-brown colours, in age, of many other species of the genus, when fresh it has the whitish tomentum with bluish areas similar to that found in *H. sauveolens.* It differs from this latter species in the depressed cap, uneven surface of the pileus, less fragrant and less persistent odour, and the lack of the deep indigo coloration of the stem context.

* — **diabolus** Banker. Under conifers, Salmon River region, July 15, 1931 (1039); Aug. 1, 1931 (1173a) Aug. 13, 1931 (1173b); Upper Brookside, July 28, 1931 (1173). This species is usually gregarious, sometimes complicate. Pilei stout obconic, expanding with age, 2–12 cm. broad, convex or only slightly depressed, surface smooth, even or slightly undulate, covered with a dense cottony tomentum. The very young plants are stout obconic and white, soon showing pinkish to cinnamon spots that exude a bright red juice. As they mature, the plants become variegated with salmon, reddish, red-brown, or blackish areas (vinaceous-cinnamon, "tawny", "madder brown", "garnet brown", "maroon" or "black"), turning dark red-brown to black where bruised. Margin obtuse at first, thinning out at maturity. Stem central to lateral, sometimes short, stout, usually elongate, rooting in the moss or duff, 1–7 × 0.5–2.5 cm., covered with a tomentum that is at first white but soon turns cinnamon-brown or black where bruised. Teeth terete, up to 3 mm. long, shorter towards the margin, somewhat decurrent, "light Congo pink" to "Japan rose" at first, becoming red-brown to black. Context duplex, surface layers spongy, interior tougher, radiately fibrous, pinkish-cinnamon to red-brown, zonate. Spores subglobose, rather dark yellow-brown, tuberculate, 2.5–5.5(6) μ in diameter. Odour woody-fragrant when fresh. Taste tardily acrid. Plants drying a dull reddish-brown with surface tomentum somewhat strigose under the lens.

This species is also quite abundant under conifers and can be distinguished by the reddish juice and reddish colorations of the pileus. The plants described by Coker (11) under this name have a more salmon coloration and a colourless juice.

— **floriforme** (Schaeff.) Banker. Under conifers, Economy Lake, Aug. 31, 1927 (67), coll. A. R. Prince (6230); Salmon River region, July 15, 1931, coll. A. H. Smith (1040); Victoria Park, Truro, Aug. 17, 1931 (1040a). Plants variable, characterized by the presence of orange-coloured tomentum upon the pileus or at least upon the stipe. Colour variable, young plants usually pure white, becoming light orange. In some plants the orange coloration is retained, even after drying. In others the tomentum turns darker, becoming orange-brown to olive-brown ("light salmon-orange" or "bittersweet pink" to "orange-chrome", "dragon's-blood red") or almost black. Teeth white at first, becoming vinaceous- to olive-brown, shorter towards margin, not decurrent on stem tomentum. Context tough-fibrous with a cottony soft outer layer, dull yellow- to olive-brown or orange-brown, somewhat zonate. Spores oblong to spherical, tuberculate, pale yellow-brown, 4–5.5(6) × 2.5–5 μ. Odour, woody-fragrant; taste, farinaceous.

As figured by Schaeffer (24) and accepted by Banker (2) in his description, *H. floriforme* includes a wide range of forms. Two rather distinct groups were recognizable, however, in the Nova Scotian collections, agreeing with the *H. compactum* Pers. and *H. hybridum* Pers. or *H. aurantiacum* (Batsch) Alb. & Schw. as mentioned by Banker (2, p. 160). Collection No. 67 contains plants similar to those collected about Ann Arbor, Mich., and as pictured by Coker (11, Plate 19), which fit very well Schaeffer's

Plates 146, Fig. 4, and 147, Figs. 5 and 6, and Batsch's (4) Plate 11, Figs. 222*a*, *b*, and *c* (*H. hybridum* of Persoon or *H. aurantiacum* of Fries). These plants are slighter in stature with thinner margins and more uneven, colliculose, or compounded pilei. They have more depressed or concave surface and are more brilliant orange in their colour, which is retained longer, being present usually in the dried plant. The remainder of the Nova Scotian collections are represented well by Figs. 1–3, 5, and 6 of Schaeffer's Plate 146 (*H. compactum*). These plants are pure white at first, stouter, obconic with convex surfaces and thicker margins. The young plants are cottony tomentose at first and soon take on deeper orange-brown, olive-brown, or red-brown shades. In the older plants of this group, the colorations are duller and present only in local areas of the pileus or, more commonly, the stipe. Sufficient collections have not been made to determine whether these two groups are distinct, and as most writers consider them variations of one species, they are here united. It would be interesting to determine, however, whether *H. compactum* is a more northerly form, as seems possible.

*— **geogenium** (Fr.) Banker. Under conifers, Upper Brookside, Aug. 28, 1931 (1419). Plant squat, 4–7 cm. across; stem short, appearing almost sessile, inconspicuous. Pileus complicate, usually with a number of more or less fused stems arising from a common mass of olive-brown to black tomentum from which extends the greenish-yellow mycelium which is the key colour to the plant. Pilei irregularly circular, around the central stem mass, olive-black in the centre shading to dark olive-brown with areas of light yellow-brown or white towards the margin (probably lighter in young plants), somewhat depressed, radiate fibrillose, appressed tomentose, surface roughened, rugose to scrobiculate, complicate, often with smaller pilei arising from the surface; margin thin, often imbricate with such pilei. Substance watery-spongy, somewhat fibrous, dark olive-green or with yellow-brown areas. Individual stems small, up to 1 cm. long and 2–4 mm. in diameter, olive-brown, fused together with a mass of tomentum 1–3 cm. across. Teeth cinereous to vinaceous-brown, somewhat glaucous, tips bright greenish-yellow ("citron yellow" to "pale lemon yellow"), up to 3 mm. in length, only slightly shortened towards margin, decurrent on stem. Spores subglobose to oblong, pale-yellowish, tuberculate, $3.5\text{–}4.5 \times 2.5\text{–}3.5\ \mu$. Odour slightly woody-fragrant.

This collection agrees perfectly with Fries' (14, p. 9, Plate 8) description and figures. Banker (2, p. 135), in 1906, recorded a collection of this species from New York by Peck, stating he considered the determination "not wholly satisfactory". Later (3), he states that this collection is typical of the species as found in Europe. This Nova Scotian collection, therefore, stands as an interesting link between the European range and its single previous occurrence in eastern North America.

*— **mirabile** Fr. On needle duff under conifers. Victoria Park, Truro, July 23, 1931 (1118). Plants very squat, appearing almost sessile or buried in the duff on account of a short stipe, obconic to almost hemispheric, centrally stipitate. Pileus rather bright yellow-brown, turning darker as the light, yellowish, watery juice exudes over the surface and turning lighter again upon drying. Surface covered with a thick, dense tufted, strigose-tomentose upper layer, convex, fairly even or irregularly roughened. Margin thick, rounded, glabrous, lighter in colour except where the juice is pressed out, and then darker, hygrophanous. Stem short, stout, $1\text{–}2.5 \times 1\text{–}4$ cm., mostly buried in the duff, often appearing confluent, but pilei mostly regular, sometimes with a brownish tomentose covering. Teeth short and stout towards the margin, longer cylindric-pointed towards stem, 3 mm. long, light brown with lighter coloured tips, decurrent on stem. Substance watery-tough, upper portion spongy-hairy, giving a duplex context, dark brown from juice, hygrophanous, zonate. Spores brown, tuberculate, spherical, 4–5 μ in diameter. Taste rather acrid, odour slightly fragrant.

These plants are characterized by their stout, squat, convex build, their light-brown colour, their densely strigose-tomentose surface and very watery-hygrophanous character, the yellow juice staining the flesh dark brown wherever bruised. The only plant that seems to approach these characters is *Hydnum mirabile* Fr. Fries' figure (14, Plate 3,

Fig. 2) of this species shows a plant with similar build and strigose tomentosity, but the colour is too light and too yellowish for our plants. It may be that the colour turns darker with age or that these plates do not express the colour accurately. In 1896, Peck (23, p. 112) reported what he considered as *H. mirabile* from New York. He gave the odour as farinaceous and the taste as similar but becoming peppery. He remarked especially upon the duplex character of the context, which set it off from *H. acre* of Quélet. He gave the colour as greyish-buff to brownish-buff. Lloyd (18, Letter 49, p. 12; 51, p. 4; 53, pp. 9, 11; 58, p. 5) states that *H. mirabile* is rarer in Europe than in eastern America and that Peck's plants are this species and the same as a species collected by Atkinson and named by Bresadola as *H. cristatum* (1, p. 119), but differs from *H. acre* Quél. in the surface of the pileus and the softer context. Atkinson (1, p. 119) gives the pileus as "ochre-yellow, covered with numerous strigose hairs in the form of crests". Our plants agree with these American descriptions of *H. mirabile.*

— **parvum** Banker. On spruce duff, Salmon River region, Aug. 13, 1931, coll. A. H. Smith (1296). This is the plant first described as *H. zonatum* (Batsch) Karst. by Banker (2), but later (3) found to be distinct from the European species. This collection agrees in all respects with Banker's description, except that the teeth are sometimes longer (up to 2 mm.) and somewhat decurrent, and that the spores are larger ($4–5 \times 3.5–4\ \mu$).

* — **suaveolens** (Scop.) Karst. Under fir and spruce, Salmon River region, July 14, 1931, coll. A. H. Smith (1035); Aug. 1, 1931, coll. A. H. Smith (1035a); Victoria Park, Truro, Aug. 17, 1931 (1035b); Upper Brookside, Aug. 28, 1931, coll. A. H. Smith (1035c). Plant rather stout and squat, 4–15 cm. in diameter. Pileus obconic, thick, convex or plane, surface rather even or slightly undulate, white at first, covered with a thick velvety tomentum, turning watery grey to light olive-brown where bruised. Margin thick, sterile. Stem usually short and stout, 2–4 cm. long, 1.5–2 cm. thick, covered with a spongy tomentum which shows shades of bright blue ("pale blue-violet" to "dark dull violet-blue") or patches of white. Teeth terete, short, blunt at first, becoming long and slender (up to 6 mm.), shorter towards margin, somewhat decurrent, whitish at first, then glaucous bluish and finally brownish from the base upwards. Substance duplex, upper layer soft spongy, white, inner portions tough, radiate-fibrous, drying woody, somewhat zonate, whitish above, shading into a deep indigo-blue below and in the stem. Spores small, subglobose, hyaline to light yellowish, tuberculate, $3.5–5 \times 3–4\ \mu$. Odour strongly fragrant, long persistent, even in dried plants. Taste none or mealy.

This northern species was abundant under fir and spruce and is easily distinguishable after one becomes acquainted with the plants in various stages. The smooth, convex, white, velvety surface, bluish tomentum on the stipe, bluish teeth, strongly fragrant odour and deep indigo coloration of the substance of the stem are all good diagnostic characters that are retained in the dried plants.

* — **zonatum** (Batsch) Karst. Under conifers and hardwoods, Princeport (65), coll. A. R. Prince (6227); Killag Mines, Halifax Co., July 30, 1931 (1181). This is the species formerly referred to by Banker (2) as *H. concrescens* (Pers.) Bank. The plants from Killag Mines are not particularly zonate but are more radiately rugose or scrobiculate. They may be *H. scrobiculatum* or *H. hybridum*, but until better series are obtainable they should remain here.

Hydnum repandum L. On soil under conifers, Upper Brookside, July 31, 1931, coll. A. H. Smith (1193); Wentworth Valley, Cumberland Co., Aug. 29, 1931 (1193a); Princeport, Aug. 20, 1927 (57), coll. A. R. Prince (6225).

* **Phellodon coriaceo-membranaceus** (Schw.) Banker. Under spruce, Upper Brookside, Aug. 14, 1931, coll. A. H. Smith (1303); Economy River, Aug. 31, 1927, coll. A. R. Prince (6231). Banker (2) gives this species as differing from *P. tomentosus* in the larger pilei which are less confluent and in the stronger odour. The collections referred here, which have larger pilei (1.5–7 cm.) and are less confluent than those referred to *P. tomentosus,* had a slightly fragrant odour, but this odour was actually less strong than that of the

small plants referred to *P. tomentosus*. It seems doubtful whether this odour is a constant character.

— **tomentosus** (L.) Banker. Under spruce and fir, Victoria Park, July 23, 1931, coll. A. H. Smith (1122); Salmon River region, Aug. 18, 1931 (1122a). The plants referred to this species were smaller (1.5–3 cm.), more densely confluent, and possessed a pungent, asafoetida-like odour, which is retained in the dried plants, in contrast to the slightly fragrant odour of the *P. coriaceo-membranaceus* plants.

* — **vellereus** (Pk.) Banker. Under hardwoods, Folleigh Lake, Aug. 29, 1931, coll. A. H. Smith (1430). Although these plants have a sweetish, putrid, asafoetida-like odour when fresh, similar to that given for *P. putidus*, they are smaller than that species and agree more closely with the descriptions of *P. vellereus*.

* **Sarcodon radicatus** Banker. On soil under upturned stump, conifer woods, Portapique Beach, Aug. 7, 1933 (1615).

* **Sarcodon stereosarcinon** (†) sp. nov. (Plate I). On soil under conifers, Victoria Park, Truro, Aug. 23, 1929 (262); Upper Brookside, July 4, 1931 (380); Aug. 1931 (380a). Pilei 3–12 cm. in diameter, centrally stipitate, lobed or complicated with several pilei springing from a common stalk, rather thick-fleshy-fibrous, tan to tawny, pale cinnamon- or reddish-brown ("vinaceous-cinnamon"), glabrous, minutely velvety-tomentose or cracking with age and then appearing somewhat scaly. Margin irregular to lobed, thin, light coloured beneath, sterile. Stipe central, eccentric or lateral, 2–10 cm. long, 1–2 cm. in diameter, sinuous or compound, tapering downwards, dirty-brown, smooth, solid, drying hard and woody. Teeth crowded, slender, terete or flattened, short and whitish at the margin, elongating rapidly and becoming dull brown from the base upwards, the light tips giving a cinereous-brown sheen in mass, strongly decurrent on the stem, sometimes falling away and then leaving small pits with an intervening raised reticulum. Context radiating fleshy-fibrous, whitish, or darker in stem, drying hard and brittle. Spores pale brown in mass, hyaline under the microscope, globose to ovoid, coarsely tuberculate, $3.5–5 \times 2.5–4\ \mu$. Odour strongly farinaceous.

This Sarcodon, which is intermediate between this genus and Hydnellum, is the most abundant in the province. It is common in moist seasons in open coniferous woods, occurring in large troops. Its disposition is a difficult one. In a previous paper (28), the writer referred to these collections as *Sarcodon montanus* on the basis of a specimen collected by Kauffman at Lake Cushman, Washington, and labelled *Hydnum montanum* (in Herb., Univ. of Michigan). Further examination has thrown doubt upon the identity of these plants, particularly in the absence of notes on the fresh condition of Kauffman's plant. Kauffman's plant has very thin flesh and a stout stem which is stuffed with a spongy reticulate mass of dried tissue, whereas the Nova Scotia plants have a relative thick, firm, white flesh and a solid stipe which dries firm and woody. Kauffman's material was sent to Lloyd who replied as follows "A fleshy plant with hyaline tuberculate spores, rare characters and only present in *H. fragile* (equals *H. reticulatum*, letter 54, note 224) and this is surely not this plant; probably unnamed". Lloyd's note 224 refers to a collection made by Miss Hibbard in Nova Scotia and referred by Lloyd to *H. reticulatum*.

† **Sarcodon stereosarcinon** *sp. nov. Pilei 3–12 cm. diametro, stipite centrali, lobati complicative aliquot stipite unico adscendentes, aliquantum crassi-carnoso-fibrati, fusci, fulvi, pallido-cinnamomini vel rubro-brunnei, (vinaceo-cinnamomini Ridgewayi), glabri minute velutino-tomentosi vel vetustate dehiscentes deinque aliquantulum squamosi visi. Margo irregularis vel lobatus, tenuis, infra pallidus, sterilis. Stipes centralis, excentricus vel lateralis, 2–10 cm. longus, 1–2 cm. diametro, sinuosus vel compositus, ad basim attenuatus, sordide fuscus, glaber, solidus, rigidus lignosusque exsiccatus. Dentes conferti, gracilis, teretes vel complanati, margine breves et alb velociter producentes et e basi sursum obscuro-fusci, apices lucidi cumulo nitorem cinereo-fuscum parientes, admodum in stipitem decurrentes, nonnunquam cadentes denique lacunas pusillas reticulum interiectum elevatumque creantes. Contextus albidus, stipite minors albido, carnoso-fibratus confluens rigidus fragilisque exsiccatus. Massa sporarum pallido-fusca. Sporae translucidae, globosae usque ad ovatae, crasse tuberculatae,* $3.5–5 \times 2.5–4\ \mu$. *Odor farinaceus.*

PLATE I. *Sarcodon stereosarcinon sp. nov.*

Miss Hibbard's plants "grew in troops", had hyaline tuberculate spores, dried wood-brown with paler flesh and had flattened decurrent teeth which left a reticulum when broken off. All these characters, as well as Lloyd's photograph (18, Letter 56, Fig. 715) agree perfectly with our own Nova Scotia collections, and there is little doubt that they are the same species.

This is not Banker's *Sarcodon reticulatus*, however, as is shown by an examination of the type distribution (Ellis, N. Am. Fung. 929). *S. reticulatus* is a lighter colour and intermediate in thickness of flesh. The reticulations in this species, from which the specific name is taken, are the flattened and confluent bases of the teeth, forming definite raised ridges. Reticulations can be found in *Sarcodon stereosarcinon* also, and were noted as a "minor feature" by Lloyd. These reticulations are of a different sort, however, and are caused by the presence of a sunken, circular pit or depression where the older teeth fall away from the pileus, the ridges being the intervening anastomosing reticulum of pileus tissue.

All three of these species are similar in general appearance and in the hyaline tuberculate spores, but *Sarcodon stereosarcinon* differs in the stouter, thicker build, firmer, more fibrous flesh, and somewhat darker coloration. The plants also tend to be more complicate and in this condition resemble closely Fries' figures of *Hydnum versipellis* (14, Plate I), but are a more tawny- or cinereous-brown and are not so definitely scaly.

Polyporaceae

The collections of Poria were examined by D. V. Baxter, and unless otherwise indicated the determinations of this genus are his. The writer is also indebted to J. L. Lowe for the determination of a number of species of Polyporus and for helpful suggestions as to the disposition of others.

Porothelium fimbriatum Fr. On Betula, Salmon River region, July 14, 1931 (1016); New Glasgow Road, July 25, 1931 (1151); on Fagus, Upper Brookside, Aug. 11, 1931 (1278); on Populus, Upper Brookside, Aug. 11, 1931 (1279). Quite common, reported from the Province as *P. Friesii.*

Merulius lacrymans Fr. On conifer cord wood, at the base of a moist pile in a shed, Truro, Aug. 30, 1933, *fide* M. A. Donk (1639).

* — **porinoides** Fr. On Fagus, Upper Brookside, July 1, 1933, det. M. A. Donk (1570). Donk remarks "as far as I know, new to the American continent". This species is very similar to *M. crispatus, M. serpens*, and *M. ceracellus.* The last species is an American one. This collection has smaller pores (3 per mm.) and somewhat smaller spores (2.5–$3.5 \times 2\ \mu$) than are given for *M. porinoides.* On the other hand, it is thicker (500–800 μ), has somewhat larger pores than *M. ceracellus*, and has clamp connections on the hyphae, which Burt states are not present in that species.

The fruit bodies are widely effuse, somewhat separable, white at first, and at the margins, then "massicot yellow" and with a smooth surface, which is later pushed up into irregular anastomosing ridges which form the pore surface which is darker brown ("reed yellow" to "olive-buff").

* **Poria ambigua** Bres. Inside of stump, Upper Brookside, Sept. 4, 1931 (1470); on Populus, Victoria Park, Truro, July 18, 1933 (1586).

* — **attenuata** (Pk.) Cke. On Fagus, Upper Brookside, July 30, 1929 (188); Aug. 11, 1931 (1270); on Salix, Victoria Park, Truro, July 23, 1931 (1119); on Betula, Middle River, Victoria Co., Aug. 5, 1931 (1232). This species is considered the same as *P. eupora* Karst., *P. Blytii* Fr., and a number of other species by Baxter.

* — **corticola** (Fr.) Cke. On Populus (?), Upper Brookside, June 28, 1931 (314).

* — **ferrea** (Pers.) Romell. On Alnus, Victoria Park, Truro, July 18, 1933 (1592). This species is known under the name of *Polyporus ferreus*, but is resupinate and is better in the genus Poria.

* — **ferruginosa** (Schrad.) Fr. On Fagus, Upper Brookside, June 29, 1931 (327). Baxter states that no spores were found in this material and that the determination could not be certain, but the plant belongs in the *P. ferruginosa* group.

* — **punctata** Fr. On Salix, Victoria Park, Truro, July 23, 1931 (1126).

* — **semitincta** (Pk.) Cke. On decayed wood, Salmon River region, Aug. 1, 1931 (1206); on Betula, Mt. Thom, Aug. 10, 1931 (1246).

— **subacida** (Pk.) Sacc. On conifer logs, Killag Mines, Halifax Co., July 30, 1931 (1186); Mt. Thom, Aug. 15, 1931 (1316); Victoria Park, Truro, Aug. 15, 1933 (1627).

* — **subincarnata** (Pk.) Murr. On conifer log, Upper Brookside, July 11, 1931 (491); on Abies, Middle River, Victoria Co., Aug. 5, 1931 (1231).

— **vulgaris** Fr. sensu stricto ex Romell non Bresadola. On Abies, New Glasgow Road, June 30, 1931 (338).

* — **xantha** Lind. On Populus, Salmon River, Aug. 13, 1931 (1298).

* **Poria sp.** On *Abies balsamea*, Victoria Park, Truro, Aug. 8, 1929 (234). Baxter states that this collection represents the type of plant which has been called *Poria flavicans* Karst. in America. A study of many American collections and a recent comparison with European material has convinced him, however, that these American collections are not the *P. flavicans* of Karsten, but represent a new species which he hopes to describe later.

Polyporus abietinus Fr. On *Abies balsamea*, Victoria Park, Truro, Aug. 8, 1929 (222). Although often considered as merely a growth or host form of *Polyporus pargamenus*, these effuse reflexed forms on coniferous wood are definitely distinct from the large dimidiate or imbricate, more yellowish pilei common on hardwoods. This collection shows the irpicoid or lamellate condition of the pores, the hymenophore consisting strictly not of pores at all, but branched lacerate lamellae that radiate out from numerous centres of growth. This condition is the *Irpex fusco-violaceus* of Fries, the lamellate condition being even more pronounced here than in the figure shown by Lloyd (17, p. 1230).

— **adustus** Fr. On Populus, Victoria Park, Truro, Oct. 3, 1925, coll. A. R. Prince (88); Upper Brookside, July 27, 1931 (1163).

— **albellus** Pk. On Betula, Folleigh Lake, Aug. 13, 1927, coll. A. R. Prince (6041); on *Acer saccharum*, Upper Brookside, Aug. 1, 1929 (197); on Fagus, Folleigh Lake, July 20, 1931 (1091); Salmon River region, July 15, 1931 (1043). Common on hardwoods. Inasmuch as *P. albellus* seems to be the only name definitely fixed for the species complex including such names as *P. trabeus* Fr., *P. chioneus* Fr., and *P. lacteus* Fr., and inasmuch as various writers are unable to agree whether these species are distinct and what characters should be used for distinction, all the collections falling in this group are placed here.

* — **anceps** Pk. On Pine (?), Salt Springs, Pictou Co., Sept. 2, 1925, coll. A. R. Prince (42). This plant fits the conception of this species given by Kauffman (15) rather than that of the western plants that turn sordid red with age, mentioned by Lloyd (17, p. 655) and Kauffman. In this plant the margin becomes yellowish-brown, the pores, context, and most of the surface remaining pure white.

— **balsameus** Pk. On *Abies balsamea*, Upper Brookside, Aug. 14, 1931 (1308); Sept. 3, 1931, coll. A. H. Smith (1308a). These plants were found on the roots and bases of fir and were determined by J. L. Lowe. They were sessile, dimidiate, imbricate, 2–7 × 1–3 × 0.2–0.5 cm., watery, tough-fibrous, and zonate with shades of yellow-brown, greyish-brown and greyish-white. The surface was radiately fibrous-tomentose and the margins obtuse, sterile, often white-tomentose and somewhat undulate. Context watery-white, 1–2 mm. thick; tubes 0.5–4 mm. long, mouths white, round, or sometimes sinuous or almost daedaloid, 3–4 per mm. Spores ellipsoid, 3.5–4 × 1.5–2.5 μ, hyaline. Odour disagreeable.

— **benzoinus** Fr. (*P. fuscus* Pers., *P. resinosus* Fr.). On *Tsuga canadensis*, Upper Brookside, Sept. 3, 1931, coll. A. H. Smith (1468). This may be merely a form of *P. resinosus* as held by Overholts (21, p. 47) and others, but these specimens fit so perfectly the concept of *P. benzoinus* recognized by Lloyd (17, p. 333, 334) on conifer hosts that they are placed here under that name. The surfaces of the pilei are dark chocolate-brown, definitely hispid and with bluish-black zonate bands, obvious even in the dried plants. The pore mouths are pale yellowish-white at first, the rest of the pore being brown. Later the pore mouths turn darker or blackish where bruised and remain firm in drying. The plants have a pungent fragrant odour when fresh.

— **betulinus** Fr. On Betula, West River, Salt Springs, Pictou Co., Sept. 2, 1925, coll. A. R. Prince (83). Very common throughout the Province on birch.

— **borealis** Fr. On living roots of spruce, Victoria Park, Truro, Aug. 17, 1931 (1324); Sept. 1, 1931, coll. A. H. Smith, det. J. L. Lowe (1324a). These plants are somewhat thinner (0.5–1 cm.) than is given in most descriptions and often formed erect, circular, fasciculate clusters about a central point of attachment. Spores ellipsoid, apiculate, light yellow-brown in mass, 5–5.5 × 3.5 μ. Odour sweetish. Taste slightly nauseating.

— **caesius** Fr. On beech (?), Salmon River region, Sept. 7, 1931, det. J. L. Lowe (1481).

— (***Trametes***) **cinnabarinus** Fr. Economy Lake, June 17, 1926; on Fagus, Folleigh Lake, Aug. 23, 1927 (87); on Betula, Mt. Thom, Aug. 11, 1927, coll. A. R. Prince (6161); Folleigh Lake, Aug. 18, 1927, coll. A. R. Prince (6073).

*— **cinnamomeus** Fr. On mossy soil, Lake O'Law, Inverness Co., Aug. 6, 1931 (245a). A small, silky, bright cinnamon coloured plant in contrast to the common *P. perennis*, which is usually found on sandy soil. Although the spores seen in this plant were immature, measuring about 5 × 2.5–3.5 μ, they show the characteristic differences from those of *P. perennis*, as pointed out by Lowe (20, p. 45), that is they are stout ellipsoid, often slightly inequilateral, have no central oil globule, and are somewhat apiculate. The tramal hyphae are thick-walled, unbranched, and 10–12 μ in diameter.

— **circinatus** Fr. On soil under conifers, particularly spruce, Victoria Park, Truro, Aug. 17, 1931, coll. A. H. Smith (1325); Upper Brookside, Aug. 20, 1931, coll. A. H. Smith (1325a); Salmon River region, Aug. 1931.

— **confluens** Fr. On soil at base of Abies, Victoria Park, Truro, July 22 and Aug. 17, 1931, coll. A. H. Smith (1115a, 1115d). In the fresh condition this species is often easily confused with *P. ovinus*, but the differences, especially of the dried plants, mentioned by various authors are shown by these collections also. Number 1115a shows the fasciculate condition with fused stems. In drying, the surface of the pileus becomes yellowish-buff or black where bruised, but always shows more or less of the reddish coloration characteristic of this species. The pores, context, and stem also show these flesh, red-orange, or red-brown tints. Spores ellipsoid, apiculate, with a single oil droplet, 3.5–4.5 × 2–3 μ.

— **elegans** Fr. On decayed sticks, Upper Brookside, July 24, 1929 (112).

*— **fagicola** Murr. On Fagus, Folleigh Lake, July 20, 1931, det. J. L. Lowe (1092); Upper Brookside, July 1, 1933 (1092a). According to Lowe, this species represents a smooth, small-pored form of *P. squamosus* or a small-pored form of *P. pennsylvanicus*, if it can be recognized as a species at all. The cap is smooth to radiately appressed- and scaly-tomentose.

*— **fibrillosus** Karst. On *Abies balsamea*, Mt. Thom, Aug. 10, 1931. det. J. L. Lowe (1249).

*— **fragilis** Fr. On conifer log, Earltown Road, Aug. 21, 1931 (1377); on spruce log, Salmon River region, Sept. 7, 1931, det. J. L. Lowe (1477).

*— **glomeratus** Pk. On a maple log, Mt. Thom, Aug. 10, 1931 (1248). Found effused over wide areas on the under side of the log but becoming reflexed at the margins, which seems to be the characteristic position of this species. This collection shows the typical,

large, dark-brown, seta-like hyphae as pointed out by Lloyd (18, Letter 54, p. 4) for this species. These hyphae are imbedded for the most part in the trama but may project through the hymenium and then appear as setae, which Lloyd (17, p. 1012) later pointed out to be a variable condition. The yellowish spores of this plant vary from globose to broad ellipsoid, 3.5–5.2 × 3–3.5 μ, rather than being globose and 5–6 μ as given in most descriptions. When fresh, the pore surface has a characteristic sheen, being silver-white to grey when the light is reflected from the white pore mouths and greenish- to olive-brown when the light is reflected from the interior of the tubes.

* — **guttulatus** Pk. On conifer stub, Mt. Thom, Aug. 10, 1931 (1247); on Hemlock, Mt. Thom, Aug. 15, 1931, coll. A. H. Smith, det. J. L. Lowe (1321). The spores were ellipsoid, hyaline and 3.5 × 2 μ. Odour slightly fragrant.

* — **hirsutulus** Schw. On *Acer pennsylvanicum*, Upper Brookside, Aug. 12, 1931 (1291). This may be merely a form of *P. versicolor*, but it is lighter in colour, more strongly hirsute, has a yellowish pore surface, and is more effuse-reflexed with small pilei.

— **hirsutus** Fr. On Betula, Economy Lake, June 16, 1926, coll. A. R. Prince (17); on Fagus, Folleigh Lake, July 20, 1931 (1096 & 1097); Salmon River region, Aug. 18, 1931 (1096a).

* — **hirtus** Quél. At base of Abies, Earltown Road, Aug. 26, 1931, det. J. L. Lowe (1115b). Although this plant is centrally stipitate, it fits very well the description given by Shope (25, p. 357). The spores were immature, elongate-ellipsoid with a curved apiculus at one end, hyaline and 9–10 × 3.5 μ. Although fairly common in the west, this species seems to be rather rare in the eastern states.

— **lucidus** Fr. On old stump, Victoria Park, Truro, Aug. 8, 1929 (247). Fairly common and reaching a great size on conifer logs.

* — **nidulans** Fr. On *Betula alba*, New Glasgow Road, July 25, 1931 (1134); on Fagus, July 30, 1931, det. J. L. Lowe (1184)

* — **ovinus** Fr. On soil, Victoria Park, July 22, 1931, coll. A. H. Smith (1115); Upper Brookside, Aug. 31, 1931 (1115c). In contrast to *P. confluens* (see notes under that species), these plants grow singly and are centrally stipitate. Upon drying, the pileus and pore layers are pale yellowish-olive, or blackened where bruised. There is often a pinkish flesh coloration at the base of the stem, but not over the whole plant as in *P. confluens*. When fresh the cap turns bluish very slowly where bruised. The spores of 1115c were broad ellipsoid, apiculate, and 4.5–5 × 3–3.5 μ.

— **pargamenus** Fr. On hardwood stubs and logs, Middle River, Victoria Co., Aug. 5, 1931 (1503); Princeport, Aug. 26, 1927, coll. A. R. Prince (6160). On upright hardwood stubs the pilei of this species are formed in great numbers and reach a size of 10–21 × 6–7 cm.

— **perennis** Fr. On soil (usually sandy), Westcook's Cove, Guysborough Co., Sept. 5, 1925, coll. A. R. Prince (1052); Upper Brookside, June, 1927, coll. A. R. Prince (85); Victoria Park, Truro, Aug. 16, 1929 (245); Salmon River region, Aug. 1931 (1509). In contrast to *P. cinnamomeus*, as pointed out by Lowe (20, p. 44), the spores of these plants are symmetrical, oblong ellipsoid, have a large globule in the centre of each spore, and are 6.5–8 × 3.5–5 μ. The tramal hyphae are 4–6 μ in diameter.

— **picipes** Fr. On buried wood, Mt. Thom, Aug. 11, 1927, coll. A. R. Prince (89); Folleigh Lake, Aug. 23, 1927, coll. A. R. Prince (14).

— **radiatus** Fr. On Betula, Salmon River region, Sept. 7, 1931, det. J. L. Lowe (1248b); on Acer, Upper Brookside, Sept. 4, 1931 (1248a). The setae are quite abundant in these plants. They are dark brown, 9–10 μ in diameter and project 20–25 μ. They are sharply pointed, curved at the apex, and vesciculose at the base. Spores hyaline, subglobose, 3–4 × 2.5–3 μ.

— **Schweinitzii** Fr. On conifer roots, Victoria Park, Truro, Aug. 1929.

* — **semisupinus** Berk. & Curt. On Betula, Folleigh Lake, July 20, 1931 (1505); Upper Brookside, Aug. 11, 1931 (1205); Earltown Road, Aug. 22, 1931 (1285a); on Fagus,

Upper Brookside, Aug. 12, 1931 (1285); Aug. 14, 1931 (1307). Collections determined by J. L. Lowe.

— **sulphureus** Fr. On Betula, Mt. Thom, Aug. 1, 1929 (187).

* — **varius** Fr. On Apple, Truro, June 20, 1926, coll. A. R. Prince (6273); July 2, 1929 (216); on Maple stump, Upper Brookside, July 10, 1933 (552a). Specimens determined by J. L. Lowe. The specimens from Apple have all been collected from the same tree, which has produced a crop of sporophores every summer that the writer has visited the Province. The tree is badly decayed and begins to form fruiting bodies late in June. The same fruiting bodies continue to develop throughout the summer. A good deal of variation in colour is encountered with age. The young sporophore is watery, tough, pale cream colour to tawny yellow-brown, with a smooth or finely and minutely silky-striate surface. The pore surface is pale tawny at first and the margin is thin, sterile, and inrolled. The stem is white toward the apex but black velvety towards the base. The pilei turn darker with age, the central disc becoming yellow-brown and the radiating striae reddish-brown. The margin becomes yellowish- to reddish-brown or almost black. The pore surface also becomes darker brown and the context becomes firm and corky, yellow-brown and 5–12 mm. thick. The pilei are up to 10 cm. in diameter, eccentric or laterally stipitate, and more or less depressed at the apex of the stem, especially when young. The margin is irregularly lobed or crenate; the pores are 3–4 per mm., 1–4 mm. long and decurrent on the stem. The spores are ellipsoid, hyaline, usually apiculate, and $6–7.5 \times 2.5–3\ \mu$.

These plants are very similar to *P. admirabilis* and *P. Underwoodii*, but they are never pure white as described by Dodge (13) and others for these species. Our plants seem to be more darkly coloured and smaller than Dodge's plants, and with a lesser tendency to be clustered and infundibuliform.

The specimens from Acer are somewhat smaller (4–8 cm. broad; context 2–6 mm. thick) and the surface fibrils do not turn reddish-brown as they do on the plants from Apple.

— **velutinus** Fr. On Fagus, Mt. Thom, Aug. 15, 1931, coll. A. H. Smith, det. J. L. Lowe (1311). These plants fit very well the description given by Kauffman (16, p. 212). They are thicker than *P. versicolor*, are pure white or with greyish to greyish-brown tints when fresh, slightly colliculose or pubescent towards the point of attachment, radiately rugose, glabrous, and zonate toward the thin margin. They dry a pale creamy white.

— **versicolor** Fr. On Fagus, Upper Brookside, July 24, 1929 (101); on decayed logs, Economy Lake, June 16, 1926 and Mt. Thom, Aug. 11, 1927, coll. A. R. Prince (6269 & 6049).

* **Trametes heteromorpha** (Fr.) Lloyd. On conifer, Upper Brookside, 1933 (1655).

* — **hispida** Fr. On Populus, Salmon River region, July 3, 1931 (361).

— **Pini** Fr. On Abies, New Glasgow Road, June 30, 1931 (343); on spruce, Salmon River region, Sept. 7, 1931 (1480); Moore's Lake, Halifax Co., July 5, 1929 (33). No. 33 is the widely effuse, annual form with a single, lighter yellow-brown pore layer which is placed by some writers in *Trametes piceinus* Pk. or the variety *Abietis* Karst.

— **subrosea** Weir. On spruce, Upper Brookside, Sept. 3, 1926, coll. A. R. Prince; on fir, New Glasgow Road, June 30, 1931 (339); Victoria Park, Truro, Aug. 17, 1931 (1507).

Fomes applanatus (Wallr.) Gill. On Acer, Salt Springs, Pictou Co., Sept. 3, 1925, coll. A. R. Prince (6267); on living apple tree, Truro, Aug. 18, 1925, coll. A. R. Prince (1053).

* — **connatus** (Fr.) Gill. On *Acer saccharum*, Upper Brookside, July 27, 1929 (158).

— **fomentarius** Gill. On Acer, Westcook's Grove, Guysborough Co., Sept. 5, 1925, coll. A. R. Prince (1035); on Betula, Economy Lake, June 16, 1926 (13); on living Fagus, Upper Brookside, June 22, 1926 (57). Abundant on standing beech.

— **igniarius** Gill. On Betula, Westcook's Cove, Guysborough Co., Sept. 1925, coll. A. R. Prince (1046); Salmon River region, Aug. 13, 1931 (1506); on *Pyrus malus*, Truro, June 28,

1936; on Populus, Salmon River region, Aug. 1, 1931 (238a). This species is quite common. No attempt has been made here to separate the numerous varieties and forms that have been described. The plants from Betula are probably the variety ***nigricans*** although all types of fruiting bodies, from entirely effuse to strongly ungulate, are found. They all have a comparatively smooth upper surface, which is often light coloured. The cystidia are also quite numerous and dense, which suggests the form given by Lloyd (17, p. 247) as *F. borealis*. The resupinate forms are probably those known as *Polyporus leavigatus* or *F. nigricans* var. *laevigatus* Overh. (5, p. 430).

— **pinicola** (Swartz) Cke. On conifer logs, Economy Lake, June 17, 1926 (34); Folleigh Lake, Oct. 22, 1926, coll. A. R. Prince (6255); on living Betula, Upper Brookside, Aug. 8, 1927, coll. A. R. Prince (6258). Common.

* — **scutellatus** (Schw.) Cke. On Alnus, Upper Brookside, June 27, 1931 (305); Salmon River region, July 15, 1931 (1508).

Favolus canadensis Klotzsch. On Fagus, Upper Brookside, June 29, 1925, coll. A. R. Prince (6257); July 21, 1929 (110). Common on beech.

Daedalea confragosa Fr. On Alnus, Salmon River region Aug. 1, 1931 (1209); on Betula, Middle River, Victoria Co., Aug. 5, 1931 (1209a).

— **unicolor** Fr. On Betula, Victoria Park, Truro, Oct. 3, 1926, coll. A. R. Prince (6163); on hardwood log, Upper Brookside, July 14, 1929 (68); on Fagus, Upper Brookside, June 29, 1931 (328); Sept. 11, 1931 (68a). Nos. 68a and 6163 have the surface of the pileus light yellow-brown rather than greyish to greenish and are the *D. ochracea* of Lloyd, according to J. L. Lowe.

Lenzites betulina Fr. On Betula, Economy Lake, June 16, 1926 (5); on Fagus, Folleigh Lake, July 20, 1931 (1093).

— **sepiaria** Fr. On Abies, Moore's Lake Halifax Co., July 5, 1929 (34); Upper Brookside, June 27, 1931 (309); on buried wood, Folleigh Lake, Aug. 23, 1927, coll. A. R. Prince (6164). Common on conifer hosts.

Sclerodermataceae

Scleroderma vulgare Fr. On soil, Upper Brookside, coll. A. R. Prince (6215).

Lycoperdaceae

Bovista pila Berk. and Curt. On soil, Killag Mines, Halifax Co., July 30, 1931 (1215); beach, St. Peters, Richmond Co., Aug. 3, 1931 (1215a); Baddeck, Victoria Co., Aug. 5, 1931 (1224a); Salmon River region, Aug. 18, 1931, coll. A. H. Smith (1370).

— **plumbea** Pers. On soil, Baddeck, Victoria Co., Aug. 5, 1931 (1224); Upper Brookside, Aug. 24, 1931, coll. A. H. Smith (1405).

* **Calvatia elata** (Massee) Morgan. On old sticks, and climbing 6 in. up an old alder trunk to fruit, Upper Brookside, Aug. 14, 1931, coll. A. H. Smith (1302). Fruit body 5–8 $\times$ 4–7 cm., having an elongated, obconic stipe, 3–5 cm. long, and a globose flattened head. Outer peridium of minute furfuraceous warts or spines, which are soon deciduous; inner peridium extremely brittle, pale yellowish, becoming olivaceous. Spores globose, brown, coarsely echinulate, 4–5 μ.

Lycoperdon gemmatum Batsch. On soil or humus of decayed logs, Upper Brookside, July 17, 1931 (1076); Folleigh Lake, July 20, 1931 (1076a); Earltown Road, Aug. 22, 1931 (1076b). Very common and quite variable.

— **polymorphum** Vitt. (*L. furfuraceum* Schaeff.)†. In open pasture, Salmon River region, Aug. 18, 1931, coll. A. H. Smith (1369). Fruit body spherical to flattened, 2–3.5 cm., outer periderm of minute floccose warts (4–6 per mm.), creamy white. Chambers of gleba very minute or invisible to the naked eye. Spores globose, brown, smooth, with a large guttula and occasionally a very short pedicel, 3.3–4 μ in diameter. Capillitium of long, narrow, branched threads, about 4μ in diameter and tapering off to fine points, dark brown.

This plant is placed here on account of the unchambered gleba, narrow, dark coloured capillitium and short pedicelled, guttulate spores. The capillitial threads are long and intertwined, but taper off to pointed ends and are rather richly branched, suggesting a Bovistella more than a Lycoperdon. This is the spherical form with small sterile base, referred by Lloyd (17, p. 234) to *L. cepaeforme*. The bright olive-yellow or reddish-yellow colour of the dried plants also suggests the form placed by Coker and Couch (12, p. 93) in *L. coloratum* Pk.

— **pyriforme** Schaeff. On log, Folleigh Lake, Oct. 1928, coll. A. R. Prince (235).

* — **subincarnatum** Pk. On beech log, Upper Brookside, Aug. 12, 1931, coll. A. H. Smith (1286); on decayed wood, Earltown Road, Aug. 19, 1931 (1286a); on sawdust pile, Earltown Road, Aug. 19, 1931 (1286b). A species quite common on woody substrata, characterized by its vinaceous-brown colour ("vinaceous-fawn" to "Mikado brown") and the minute, stout-pyramidal spines of the outer cortex, which are often split, but connivent at the apex. In age the inner peridium shows as a membrane, pock-marked by numerous pits. Spores 3.5–4.5 μ in diameter, very minutely echinulate.

* — **umbrinum** Pers. On soil and humus of decayed logs, Upper Brookside, July 24, 1931, coll. A. H. Smith (1136c); July 24, 1931 (1137); Earltown Road, Aug. 8, 1931 (1136a). A small turbinate species (3–5 cm. diameter), light greyish to yellow-brown in colour (lighter below) with very fine, filiform, somewhat curved cortical spines. Spores globose, brown, guttulate, finely echinulate, 3.5–5 μ in diameter and with a short hyaline pedicel about 1μ in length.

Nidulariaceae

Crucibulum vulgare Tul. On herbaceous stems, Salmon River region, Aug. 1, 1931 (1214); on rotten wood, Economy Lake, July 1926, coll. A. R. Prince (6264).

Sphaerobolaceae

* **Sphaerobolus stellatus** Tode. On beech wood, Upper Brookside, July 1, (353); on cow dung, Upper Brookside, July 1, 1931, coll. A. H. Smith (354); on moose dung, Killag Mines, Halifax Co., July 30, 1931 (1182).

Hysterangiaceae

* **Phallogaster saccatus** Morgan. On soil above birch log, Salmon River region, Aug. 18, 1931 (1249).

Phallaceae

Mutinus caninus Fr. Around fir stump, Folleigh Lake, July 20, 1931, coll. A. H. Smith (1087). This seems to be the European species with slender cylindric stalk, sharply marked but short glebal area, no perforation of the apex, and whitish stem downwards. Coker and Couch (12, p. 10) consider *M. caninus* as probably synonymous with *M. Ravenellii*, but Lloyd, throughout, considers *M. Ravenellii* as a species which may be a form of *M. elegans*, the western American species with stouter stem tapered toward the apex and rosy throughout, a view also accepted by Stomps (27).

Dictyophora duplicata (Bosc.) E. Fischer. On soil, Upper Brookside, Sept. 5, 1931, coll. A. H. Smith (1472).

† *This specimen was sent to Lohwag, who would place it under the name L. furfuraceum Schaeff., for the reasons stated in his notes as follows: "Nach Hollos wird L. furfuraceum Schaeff. und L. pusillum Batsch von Bulliard unter dem Namen cepaeforme verwechselt und ist daher L. cepaeforme zu streichen. Da nach Hollos L. polymorphum Vitt. synonym zu furfuraceum ist, so wäre nach Hollos dieser Pilz mit furfuraceum Schaeff. zu bezeichnen. Ich sehe keinen wesentlichen Unterschied. Auch die sterile Basalpartie ist sehr dicht, was von Hollos als charakteristisch bezeichnet wird. Hollos hat furfuraceum als sehr polymorph bezeichnet."*

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PARACEONOGONIMUS KATSURADI SP. NOV. (TREMATODA : STRIGEIDA) FROM *LOPHODYTES CUCULLATUS* IN QUEBEC[1]

By L. L. Lyster[2]

Abstract

Paraceonogonimus katsuradi sp. nov. is described from *Lophodytes cucullatus*. The sub-subfamily Prohemistomini Dubois, 1938, and the genus *Paraceonogonimus* Katsurada, 1914, must be slightly modified to accommodate it.

In the course of a search for heterophyid infections in fish-eating birds in the Lake Commandant area in the Province of Quebec, trematodes were found in the intestine of *Lophodytes cucullatus*, the hooded merganser, which upon casual examination appeared to belong to *Apophallus*. It was only when specimens were stained and mounted and the holdfast organ recognized that it became apparent that these were members of the super-super-family Strigeida Poche, 1935. The lack of marked fore- and hind-body differentiation and the pyriform shape established the relationship to the super-family Cyathocotylides Dubois, 1936, and the family Cyathocotylidae Poche, 1925. The nature of the holdfast organ, the testes, the vitellaria, and body shape were those found in the super-subfamily Prohemistominae Lutz, 1935. Though the vitellaria were not entirely limited to the post-acetabular region as in the sub-subfamily Prohemistomini, the material seemed of such obvious relationship that it was assigned to this group. The presence of an acetabulum, the lack of a specialized terminal structure, and the absence of a marked ventral pit then identify this parasite as a member of the genus *Paraceonogonimus* Katsurada, 1914. The definition of the genus describes it as a Prohemistomini in which the body is ovoid. In order that the present species may be included it is proposed that this be modified to "ovoid or pyriform."

The genus was established for the type species *P. ovatus* (3). Ransom (4), misinterpreting the nature of the holdfast organ, considered it to be a Heterophyid related to *Cryptocotyle*. Ciurea (1) somewhat tentatively had suppressed the genus earlier in favour of the strigeid genus *Prohemistomum* Odhner, 1913. Szidat (5) later showed that the genus was a valid member of the Strigeida, and Dubois (2), in his monograph, treats it as a member of the sub-subfamily Prohemistomini, placing it midway between the genera *Linstowiella* and *Prohemistomum*.

[1] *Manuscript received July 22, 1939.*

Contribution from the Institute of Parasitology, Macdonald College, Que., with financial assistance from the National Research Council of Canada.

[2] *Graduate assistant.*

The sub-subfamily is defined as "Prohemistominae: vitelline follicles situated behind the acetabulum, placed near the middle of the body length, and disposed in a coronet around the holdfast organ, which is relatively well developed and hollowed by a cavity." In order that the material from the merganser may be accommodated, this definition must be slightly modified to include a species in which the vitelline follicles extend slightly anterior of the acetabulum, but are still limited to the posterior half of the body. The description of this detail would then be "Vitelline follicles situated behind the acetabulum or extending only slightly anterior to it."

The present material consists of eight specimens, of which five are egg-bearing. They are attenuate pyriform in shape, widest in the region of the holdfast organ and averaging 0.56 by 0.15 mm. in greatest measurement, with

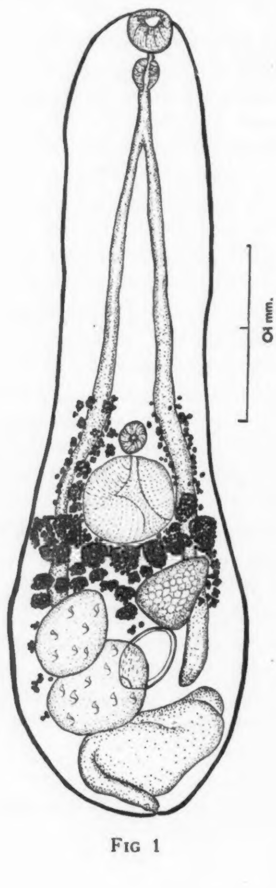

Fig 1

a maximum size of 0.63 by 0.168 mm. No cuticular spines were noted, but the cuticle was pitted as if spines might have been present before preservation. The organs are all situated in the posterior part of the body, and for this reason the post-acetabular portion is deeper than the fore part of the body, but though it is slightly hollowed ventrally there is no marked differentiation of this body region. The conspicuous but relatively weak holdfast organ, in the midline in the third quarter of the body, is 0.05 to 0.09 mm. in diameter. Anterior to it and from one-half to one-third its diameter is the acetabulum. The terminal oral sucker is 0.05 to 0.049 mm., slightly larger than the acetabulum, and is followed by a short pre-pharynx and a longitudinally ovoid pharynx about 0.05 by 0.034 mm. The oesophagus is two to four times the length of the oral sucker and opens into the crura far anterior of the acetabulum. The crura reach posteriorly to the posterior testis. The small vitellarian follicles surround the holdfast organ and are continued anterior to the acetabulum with a distinct series of follicles outlining the crura in this region; dorsal follicles are continued to the anterior region of the rear testis. The genital pore is terminal; a large and variously convoluted cirrus sac lies in the posterior extremity encroaching dorsally and laterally into the posterior testicular area, but not extending anterior of the posterior testis. The two testes are somewhat ovoid, oblique and contiguous, lying slightly to the left of the body and separated only by the cirrus sac from the posterior end. The posterior member, 0.075 by 0.08 to 0.09 mm., is larger than the other, 0.06 to 0.07 by 0.4 to 0.45 mm. The ovary, 0.05 to 0.07 mm. in greatest measurement, is roughly triangular, tending to be intermediate between the testes but on the opposite side of the body. The intra-uterine eggs, 84 by 70 μ, are always found singly.

This form differs from *P. ovatus* in several respects. It is pyriform in shape rather than ovoid, the vitellarian field is more extensive anteriorly but more limited posteriorly, and the cirrus sac is unlike that of *P. ovatus* in extent and organization. These differences serve to differentiate it from *P. ovatus*, and the material has therefore been treated as a previously undescribed species for which the name *Paraceonogonimus katsuradi* sp. nov., is proposed.

Specific Diagnosis

Paraceonogonimus: body pyriform, pre-pharynx present, oesophagus short; vitellaria surround holdfast organ dorsal and lateral to acetabulum and crura in this area, and extend dorsally to posterior testis; cirrus sac large but limited to area posterior of anterior margin of rear testis; testes oblique, ovary medial but on side of body opposite to testes.

Host: *Lophodytes cucullatus* (Hooded merganser).

Location: intestine.

Locality: Cameron's Bay, Lake Commandant, Argenteuil Co., Que.

Acknowledgments

The co-operation of the Director and staff of the Institute of Parasitology and the interest of Mr. Frank Dale, who took the mergansers, are gratefully acknowledged.

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INVESTIGATIONS ON TRICHINOSIS IN CANADA

III. ON THE INCIDENCE OF TRICHINOSIS IN GARBAGE-FED HOGS[1]

By Thomas W. M. Cameron[2]

Abstract

An examination of 995 garbage-fed hogs from Quebec, Ontario, and Manitoba, showed that only two harboured trichina larvae.

During the seasons 1937 and 1938, 2000 specimens of pork (1, 2) were examined at this Institute for the presence of trichinae. These specimens were taken at various abattoirs from Manitoba and Eastern Canada and were from *unselected* specimens. They were examined both by compression and by digestion of 10-gm. samples. They showed a general incidence of infection of 0.75%.

Recent research in the United States and elsewhere has suggested that meat-garbage fed to hogs is the main source of infection. In Canada, the Dominion Department of Agriculture requires all such garbage feeders to be licensed (and consequently to be under inspection); it further requires that all such garbage be cooked before feeding. There is no such general regulation in the United States, however. If the comparatively high incidence of trichinosis in garbage-fed hogs in that country (2) is due to this cause, it follows that, if the Department regulations in Canada are properly carried out, there should be little or no trichinosis in garbage-fed hogs in this country.

During the summer of 1939, through the co-operation of the Veterinary Director General, various abattoirs were requested to send to this Institute samples of diaphragm of hogs known to originate from hog breeders licensed to feed garbage. In this way 955 specimens were received. Apart from this, they were quite unselected. Specimens were received from Quebec, Ontario, and Manitoba only. The specimens were examined by techniques identical with those used in previous years and by the same technician who examined them in 1938. The distribution of samples is as follows.

Province	No. of samples	No. positive	Incidence
Quebec	225	2	0.88%
Ontario	283	0	0
Manitoba	487	0	0
	995	2	0.20%

[1] *Manuscript received October 7, 1939.*

Contribution from the Institute of Parasitology, McGill University, Macdonald College, Que., with financial assistance from the National Research Council of Canada.

[2] *Professor, McGill University; and Director, Institute of Parasitology, Macdonald College, Que., Canada.*

Only two specimens contained trichina larvae. The first of these was one of a lot of 17 hogs, the second one of a lot of 10 hogs. Both lots originated in close proximity to the city of Montreal.

In the previous two years' investigation, 2,000 hogs were examined. These were unselected and consequently may have contained both garbage- and non-garbage-fed hogs. While not strictly comparable with this year's examination, the cumulative figures for the three years are as follows:

Province	No. of samples	No. positive	Incidence
Manitoba	1,253	5	0.39%
Ontario	834	3	0.36%
Quebec	725	8	1.10%
Maritime Prov.	157	1	0.65%
Saskatchewan	7	—	—
Unknown	19	—	—
Total	2,995	17	0.57%

The total of 2,995 hogs, of which at least a third are known to be fed on garbage, shows an incidence of 0.57%. The known garbage-fed hogs alone show an incidence of 0.20%.

It would appear legitimate to draw the following tentative conclusions from this survey.

1. The incidence of trichinosis in garbage-fed hogs in the United States is estimated at about 5%. The much lower figure found in this survey suggests that the cooking of garbage is a reasonably sound method of preventing the condition, even although an occasional case occurs. It is probable that such a case is due to insufficient cooking, although an extraneous source of infection cannot be excluded.

2. The general incidence of porcine trichinosis in Eastern Canada appears to be considerably lower than in the United States.

3. The comparatively high figures for the Province of Quebec are probably misleading. Two cases have been definitely traced to garbage-fed hogs. All the remaining six cases (reported in 1937) were recovered from one lot of seven samples received from a single centre and it is not unreasonable to assume that they represent a single infection; this infection is possibly traceable to garbage-fed hogs also although there is no information available.

4. The figures for the Maritime Provinces are based on too few samples to be reliable. It is more probable that a figure close to 0.4% (as shown by Ontario and Manitoba) is a more representative one. Much larger numbers are necessary, however, before this can be accepted. It is probable that even this low figure could be further reduced by a more strict application of the regulations regarding garbage cooking.

Acknowledgments

The examinations were made by Mr. Angus MacMillan, and the author has to thank Dr. A. E. Cameron, Veterinary Director General of Canada, for his co-operation in this survey, and Drs. G. A. Rose, Ed. Dufresne, Ed. Grandmaison, H. H. Anderson, R. D. Boast, and I. W. Purdy, for the actual collection of the specimens. These Inspectors' assistance was invaluable and all specimens received were in excellent condition.

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REPTANT DECAPOD CRUSTACEA OF THE WEST COASTS OF VANCOUVER AND QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA[1]

BY JOSEPHINE F. L. HART[2]

Abstract

The range, size, local distribution, and notes on 44 species of reptant decapod crustaceans taken in British Columbia coastal waters are presented. A summary of records from the literature has been compiled, and the distribution of the species as a result of the peculiar configuration of the coast line is illustrated from these data.

The present paper records the range, size, local distribution, and notes on 44 species of reptant decapod crustaceans taken in the waters off the coast of British Columbia by collectors from the Pacific Biological Station. With these have been combined the records of the same species presented in the literature. Since the coast of British Columbia is probably unique in that it includes wide stretches of coast exposed to the open Pacific as well as equally large areas bordering sheltered inland passages, a summary of the records from the literature for the reptant decapods has been compiled from which an attempt is made to illustrate the difference in the distribution of the species as a result of the peculiar configuration of the coast line.

The material available consists of some 750 specimens, representing 44 species of reptant decapod Crustacea. The larger part of the collection was made in the summer of 1934 by Mr. E. G. Hart, while he was serving as Biologist for the Pacific Biological Station on the C.G.S. "Wm. J. Stewart" on the west coast of Vancouver Island. The remainder was obtained by Dr. C. McLean Fraser in 1935 when he was acting in a similar capacity on the west coasts of the Queen Charlotte Islands. The areas represented by the collections comprise the middle part of the west coast of Vancouver Island and the southern two-thirds of the west coasts of the Queen Charlotte Islands.

A few dredge hauls and shore collections in these areas, as well as along the remainder of the west coasts of Vancouver and Queen Charlotte Islands, were made by the United States Fisheries Steamer "Albatross" from 1888 to 1891 (1, 12–15). Collections were also made from the Queen Charlotte Islands by Dr. G. M. Dawson (Smith, 17), from Clayoquot, west coast of Vancouver Island, by Newcombe (10), from Ucluelet, Barkley Sound, west coast of Vancouver Island, by Macoun (Rathbun, 13–15), and from Clayoquot Sound by Spencer (18). A few records of species are also to be found in the lists of acquisitions of Crustacea in the Annual Reports of the British Columbia Provincial Museum (3). Only one-half the number of species in the present collection has been listed in these papers as occurring in localities on the west

[1] *Manuscript received October 9, 1939.*
Contribution from the Pacific Biological Station, Nanaimo, B.C.
[2] *Volunteer Investigator, Pacific Biological Station.*

coasts of Vancouver and Queen Charlotte Islands. The distribution records for the east coast of Vancouver Island, Victoria, and Friday Harbour, Washington, and northern British Columbia, are from papers listed in the references, with the exception of a few species that have been collected in the vicinity of Departure Bay by the author, but that have not been previously recorded.

One difficulty encountered is that a number of species have been reported in distribution records simply as occurring in British Columbia, since many of the early workers did not give specific localities, designating their specimens only as from "Vancouver Island", "Gulf of Georgia", "Queen Charlotte Island shore", etc. In view of the area included and of the great ecological differences involved, this is not at all satisfactory. The author has therefore endeavoured to be more specific, particularly in the case of species whose northern limit lies in British Columbia. When species are found on both east and west coasts of Vancouver Island, both localities are given as the northern range. This may be somewhat cumbersome, but is of value to local workers, and may be simplified with future collecting, when the species will perhaps be found to encircle the Island. Another difficulty is that two species have been confused, or have been recorded as one. Thus the early records for species of the genera *Petrolisthes*, *Chionoecetes*, and the rare species of *Cancer* cannot be used.

As will be seen by reference to the charts and tables included in this paper, the area concerned on the west coast of Vancouver Island was divided into a number of somewhat arbitrary regions, each of which contains consecutively numbered collection stations. The Barkley Sound area was designated as area 2211; Clayoquot Sound as 2221, 2222, and 2223; Nootka Sound as 2231 and 2232; and Esperanza Inlet as 2241, 2242, and 2243. The west coast of the Queen Charlotte Islands was considered as a unit and numbered area 3500.

In the following list, 11 species, whose northern limit lies in British Columbia, have been found farther north than previously recorded. The limit of distribution of those species that extend north and south of British Columbia has been obtained mainly from Rathbun's papers. The author is indebted to the Smithsonian Institution for the records of specimens of *Pagurus hemphillii* (Benedict) and *Orthopagurus minimus* (Holmes) from British Columbia in the collections of the United States National Museum, Washington, D.C. The size given is the length, or the length and breadth, of the carapace. The limits are the sizes of specimens in the collection.

Upogebia pugettensis (Dana)

Range. Southeastern Alaska to San Quentin Bay, Lower California.

Size. ♀ 14–35 mm. ♂10–37 mm.

Local distribution.	Esperanza Inlet area,	2241–13,	2♀	2♂
	Queen Charlotte Islands,	3529,		2♂

TABLE I

DATA CONCERNING COLLECTION OF MATERIAL

Station No.	Latitude N	Longitude W	Date	Method of collection
2211- 1	48°39′	125°46′	May 8, 1934	T 70 m.
2221- 3	49°07′45″	126°31′30″	15,	T 130 m.
8	49°10′30″	126°13′30″	14,	T 56 m.
11	48°52′	126°11′	1,	T 101 m.
14	49°46′15″	125°57′	July 5,	T 77 m.
16	48°59′45″	126°07′45″	May 1,	T 73 m.
17	49°00′15″	126°07′15″	1,	T 73 m.
18	49°02′45″	126°02′30″	1,	T 60 m.
20	49°00′15″	125°44′30″	11,	T 18–21 m.
22	49°19′45″	126°21′45″	16,	T 50 m.
25	49°14′	126°20′	23,	T 64 m.
26	49°11′	126°11′	23,	T 45 m.
27	49°10′30″	126°10′15″	23,	T 50 m.
28	49°11′30″	126°39′	June 5,	T 118 m.
2222- 4	49°09′45″	126°00′	11,	S
6	49°15′15″	126°07′	12,	S
2223- 1	49°28′30″	126°23′45″	May 29,	S
3	49°22′15″	126°28′45″	June 1,	S
2231- 6	49°08′30″	126°49′	5,	T 170–180 m.
9	49°10′	126°43′	5,	T 155 m.
10	49°13′30″	126°43′	5,	T 113 m.
13	49°21′	126°43′30″	9,	T 55 m.
14	49°23′45″	126°34′15″	May 31,	S
15	49°23′45″	126°34′15″	June 2,	S
16	49°34′45″	126°40′15″	13,	S
17	49°36′45″	126°48′15″	14,	S
18–I	49°33′30″	126°38′45″	18,	B 89 m.
19	49°31′15″	126°42′45″	19,	T 73 m.
20	49°36′45″	126°49′	26,	S
28	49°36′	126°43′15″	July 9,	S
29	49°36′	126°43′15″	10,	S
30	49°37′15″	126°49′30″	11,	S
31	49°22′15″	126°54′	12,	T 75–90 m.
32	49°31′45″	126°34′45″	13,	S
33	49°22′30″	126°55′	17,	T 137 m.
34	49°30′	126°51′	17,	T 95 m.
2241- 8	49°39′15″	126°57′15″	18,	B 45 m.
9	49°37′15″	126°50′30″	June 16,	S
11	49°40′45″	126°53′30″	27,	S
12	49°51′	127°06′15″	28,	S
13	49°45′	126°59′	July 14,	S
15	49°38′45″	127°00′	19,	T 73 m.
2242- 2	49°51′15″	127°04′45″	June 25,	S
3	49°44′	126°57′	July 24,	S
4	49°44′	126°57′	25,	S
5	49°44′	126°57′	26,	S
6	49°48′	126°58′15″	27,	S
3507	West side Louscoone Bay, 1 mile from entrance		June 4, 1935	S
3513	Head of Big Inlet		6,	T
3515	Rennell Sound between Gospel Is. and south shore.		10,	T
3516	Northeast of Marble Is.		11,	T
3519	Tasu Hbr., north shore 2 miles from entrance		14.	T
3521	Near Rose Hbr., Houston-Stewart Channel		18,	S
3525	Rennell Sound		24,	T
3526	9½ mi. south of Marble Is.		26,	B

TABLE I—*Concluded*

DATA CONCERNING COLLECTION OF MATERIAL—*Concluded*

Station No.	Latitude N	Longitude W	Date	Method of collection
3527	Near south shore, Tasu Hbr.		27,	T
3529	Canoe Passage, Skidegate Ch.		30,	S
3530	West side, eastern Skidegate Narrows		July 1,	S
3532	Skidegate Channel, near western Narrows		3,	S
3536	Flamingo Hbr.		13,	From kelp
3537	South shore, Houston-Stewart Channel		16,	S
3539	Half-tide rock, entrance Flamingo Hbr.		17,	S
3540	Rocks, entrance to Big Inlet		18,	S

T—trawl; S—shore; B—bottom.

Munida quadrispina Benedict

Range. Sitka, Alaska to Los Coronados, Lower California.

Size. ♀ 10–23 mm. ♂9.5–73 mm.

Local distribution.	Barkley Sound area,	2211–1,		1♂
	Nootka Sound area,	2231–6,	1♀	1♂
		2231–10,	1♀	7♂
	Queen Charlotte Islands,	3516,		1♂
		3525,	2♀	

Petrolisthes eriomerus Stimpson

Range. Flamingo Inlet, Queen Charlotte Islands, B.C., to Lower California.

Size. ♀ 6 × 6–12.5 × 12.5 mm. ♂7.5 × 6.5–14.5 × 14 mm.

Local distribution.	Clayoquot Sound area,	2221–25,	1♀	
		2223–3,	1♀	
	Nootka Sound area,	2231–30,	2♀	
	Esperanza Inlet area,	2241–13,		1♂
		2242–3,	1♀	
		2242–4,		3♂
	Queen Charlotte Islands,	3507,	4♀	1♂
		3539,		1♂

Remarks. This species has been previously recorded in British Columbia only from Victoria and Nanaimo, and thus its occurrence on the west coast of Vancouver Island and the southwest of the Queen Charlotte Islands constitutes a considerable extension of its range.

Petrolisthes cin.tipes (Randall)

Range. Rose Harbour, Houston-Stewart Channel, Queen Charlotte Islands, B.C., to Gulf of California.

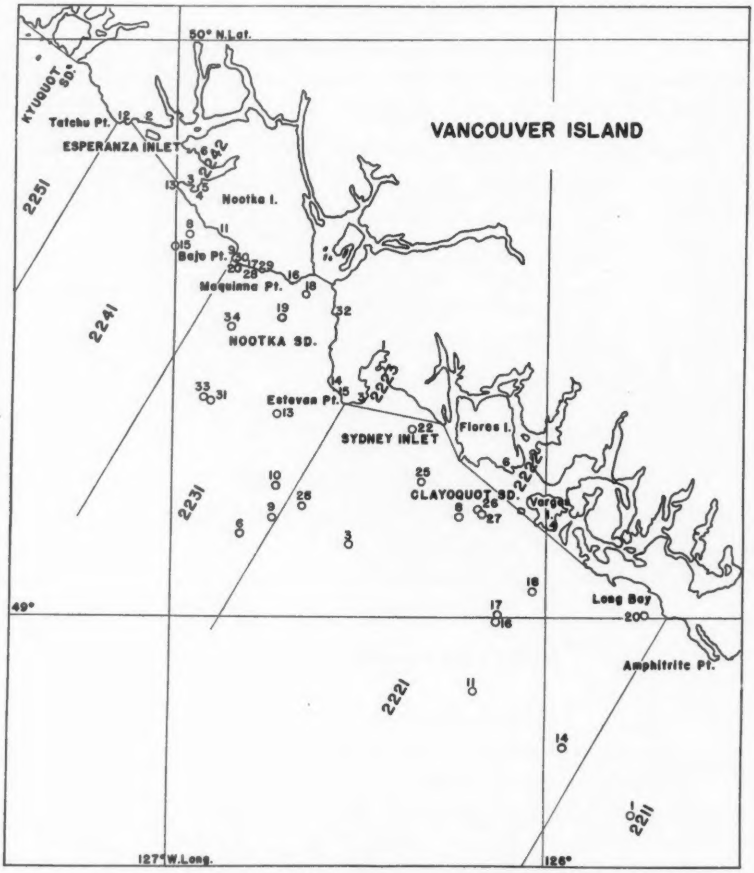

FIG. 1. *Showing locations of the following Stations: 2211-1; 2221-3, 8, 11, 14, 16, 17, 18, 20, 22, 25, 26, 27, 28; 2222-4, 6; 2223-1, 3; 2231-6, 9, 10, 13, 14, 15, 16, 17, 18-1, 19, 20, 28, 29, 30, 31, 32, 33, 34; 2241-8, 9, 11, 12, 13, 15; 2242-2, 3, 4, 5, 6.*

Size. ♀10.5 × 10.5–24 × 24 mm. ♂10 × 9–17 × 16 mm.

Local distribution.	Clayoquot Sound area,	2222–6,	1 ♀	
	Nootka Sound area,	2231–14,	1 ♀	1 ♂
		2231–30,	1 ♀	
	Esperanza Inlet area,	2242–3,	1 ♀	
	Queen Charlotte Islands,	3507,		1 ♂
		3521,		3 ♂

Remarks. This species was recorded by the early naturalists from the east and west coasts of Vancouver Island. *P. eriomerus* Stimpson was not mentioned, and as Taylor (21) states that *P. cinctipes* was common at Nanaimo, where only *P. eriomerus* is now found, it is not possible to use

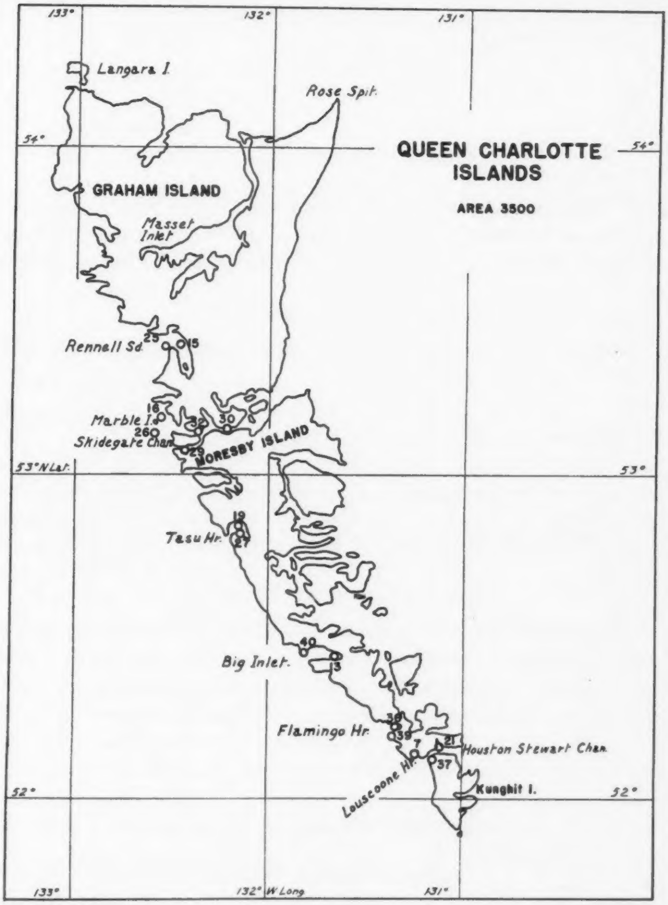

FIG. 2. *Showing locations of the following stations in the 3500 area: 07, 13, 15, 16, 19, 21, 25, 26-B, 27, 29, 30, 32, 36, 37, 39, 40.*

the early records. Since there has been no recent record of *P. cinctipes* from the east coast of Vancouver Island or from Puget Sound, it would appear that this species occurs in British Columbia only on the west coast of Vancouver Island and the Queen Charlotte Islands. Its northern known limit is extended considerably by this collection.

Pachycheles rudis Stimpson

Range. Kodiak, Alaska, to San Diego, California.

Size. ♀8 × 8–19.5 × 20.5 mm. ♂3.5 × 3.5–17 × 18 mm.

Local distribution.	Clayoquot Sound area,	2223–1,	1♀	1♂
	Nootka Sound area,	2231–16,	1♀	2♂
		2231–20,	2♀	
		2231–29,		1♂
		2231–30,	4♀	
	Esperanza Inlet area,	2242–3,	7♀	2♂
		2242–4,	2♀	6♂

Remarks. This species exhibits a great variety of colour combinations. Most are reddish in formalin, but some have a brown or purple tinge, and are mottled grey and fawn. Some looked bleached and the chelae are white.

Pachycheles pubescens Holmes

Range. Nuchatlitz Inlet, Esperanza Inlet, Vancouver Island, B.C., to Monterey Bay, California.

Size. ♂13 × 13.5 mm.

Local distribution.	Esperanza Inlet area,	2242–4,		1♂

Remarks. This is the first British Columbia record of this species and is a considerable northern extension of its range. The carapace is brick red in formalin, except for the rostrum and posterior margin, which is grey mottled with brown. The granules on the chelae are white and the inner margin is reddish.

Pagurus alaskensis (Benedict)

Range. Siberia and Alaskan coast of Bering Sea to Oregon.

Size. ♀7.5–10 mm. ♂5.5–14 mm.

Local distribution.	Clayoquot Sound area,	2221–27,		1♂
	Nootka Sound area,	2231–6,	1♀	
		2231–13,	1♀	
		2231–19,		1♂
		2231–31,		3♂
	Esperanza Inlet area,	2241–15,	1♀	1♂

Pagurus aleuticus (Benedict)

Range. Bering Sea (Pribilof Islands) to Oregon.

Size. ♀7 mm. ♂7–10 mm.

Local distribution.	Nootka Sound area,	2231–9,		1♂
		2231–33,	1♀	1♂

Pagurus ochotensis (Brandt)

Range. Unalaska to San Diego, California.

Size. ♀4–11 mm. ♂5–14 mm.

Local distribution.	Barkley Sound area,	2211–1,		2♂
	Clayoquot Sound area,	2221–8,	1♀	1♂
		2221–20,	1♀	
		2221–26,		2♂

Nootka Sound area,	2231–19,	2 ♀	1 ♂
	2231–31,	2 ♀	1 ♂
Esperanza Inlet area,	2241–15,		1 ♂
Queen Charlotte Islands,	3519,	12 ♀	12 ♂
	3527,	1 ♀	1 ♂

Pagurus brandti (Benedict)

Range. Bering Sea (latitude of Pribilof Islands) southward to Oregon.

Size. ♀ 4 mm. ♂ 4 mm.

Local distribution. Queen Charlotte Islands, 3519, 1 ♀ 1 ♂

Pagurus dalli (Benedict)

Range. Bering Sea to Oregon.

Size. ♀ 3–4 mm. ♂ 6 mm.

Local distribution.	Clayoquot Sound area,	2221–8,		1 ♂
	Nootka Sound area,	2231–19,	5 ♀	

Pagurus confragosus (Benedict)

Range. Bering Sea (latitude of Pribilof Islands) to mouth of the Columbia River, Oregon.

Size. ♀ 10 mm.

Local distribution. Nootka Sound area, 2231–9, 1 ♀

Remarks. This species has not been recorded previously from British Columbia, although found in waters north and south of this region. The colour in formalin is light, mottled with pinkish-brown dorsally except on the chelae and the centre of the hard part of the carapace. There is a greater depth of colour on either side of the distal joints of the walking legs.

Pagurus kennerlyi (Stimpson)

Range. Aleutian Islands to Washington.

Size. ♀ 3.5–11 mm. ♂ 3.5–5 mm.

Local distribution.	Barkley Sound area,	2211–1,		1 ♂
	Clayoquot Sound area,	2221–8,	1 ♀	
		2221–17,		2 ♂
		2221–18,	1 ♀	

Pagurus beringanus (Benedict)

Range. Bering Sea (latitude of Nunivak) to Monterey, California.

Size. ♀ 5 mm. ♂ 3.5–5 mm.

Local distribution.	Clayoquot Sound area,	2221–18,	6 ♀	1 ♂
	Queen Charlotte Islands,	3519,		1 ♂
		3527,	1 ♀	

Pagurus setosus (Benedict)

Range. Kodiak, Alaska, to Santa Cruz Islands, California.

Size. ♀4–6 mm. ♂4–11 mm.

Local distribution.	Clayoquot Sound area,	2221–18,	1♀	
	Nootka Sound area,	2231–9,		2♂
	Queen Charlotte Islands,	3519,		1♂
		3525,	1♀	
		3530,		1♂

Pagurus hirsutiusculus (Dana)

Range. Aleutian Islands to San Diego, California. Japan. Siberia.

Size. ♀4–7 mm. ♂4.5–15 mm.

Local distribution.	Clayoquot Sound area,	2222–4,		2♂
	Nootka Sound area,	2231–9,		1♂
		2231–28,	2♀	2♂
	Esperanza Inlet area,	2242–3,		1♂
	Queen Charlotte Islands,	3529,	2♀	
		3537,	1♀	

Pagurus granosimanus (Stimpson)

Range. Unalaska to Ensenada, Lower California.

Size. ♀6–8 mm. ♂7.5–9.5 mm.

Local distribution.	Clayoquot Sound area,	2222–6,	1♀	
	Nootka Sound area,	2231–15,		1♂
		2231–17,		1♂
		2231–20,	1♀	1♂
		2231–29,		1♂
	Queen Charlotte Islands,	3507,	1♀	1♂

Pagurus hemphillii (Benedict)

Range. Houston-Stewart Channel, Queen Charlotte Islands, B.C., to Monterey, California.

Size. ♀5–10 mm. ♂4–14 mm.

Local distribution.	Nootka Sound area,	2231–17,		2♂
	Esperanza Inlet area,	2241–12,		1♂
		2241–13,		2♂
		2242–3,	1♀	1♂
		2242–4,		1♂
	Queen Charlotte Islands,	3507,	1♀	1♂
		3537,		2♂

Remarks. These records are all north of any previously recorded specimens (those in the United States National Museum are from Barkley Sound). In formalin, the colour is dark red with white carapace dorsally, and the tips of the dactyls of all the legs and the propodi of the chelipeds are light coloured.

Paguristes turgidus (Stimpson)

Range. Rennell Sound, Queen Charlotte Islands, B.C., o San Diego, California.

Size. ♀4–13.5 mm. ♂4–22 mm.

Local distribution.	Barkley Sound area,	2211–1,		1♂
	Clayoquot Sound area,	2221–3,	1♀	2♂
		2221–14,	1♀	
	Nootka Sound area,	2231–6,	2♀	
		2231–9,	1♀	
		2231–10,	1♀	
		2231–13,	1♀	1♂
		2231–19,		1♂
		2231–31,	15♀	14♂
		2231–33,	5♀	15♂
		2231–34,	1♀	
	Esperanza Inlet area,	2241–15,	2♀	1♂
	Queen Charlotte Islands,	3515,	3♀	2♂
		3527,		1♂

Remarks. This species has not been recorded from the northern points previously.

Orthopagurus schmitti (Stevens)

Range. Esperanza Inlet, and Departure Bay, Vancouver Island, B.C., to Puget Sound, Washington.

Size. ♀3–6 mm.

Local distribution.	Barkley Sound area,	2211–1,	1♀
	Esperanza Inlet area,	2242–4,	6♀

Remarks. This is the first record of this species from outside waters, as it has been found previously only in Puget Sound and the Gulf of Georgia, B.C. It occupies empty *Serpulid* tubes.

Orthopagurus minimus (Holmes)

Range. Skidegate, Queen Charlotte Islands, B.C., to San Francisco, California.

Size. ♀3–5.5 mm. ♂4–5 mm.

Local distribution.	Queen Charlotte Islands,	3519,		1♂
		3527,	4♀	2♂

Remarks. Schmitt (16) gave the range as Queen Charlotte Sound instead of Queen Charlotte Islands. That this is an error has been verified for me by the United States National Museum. This species occupies empty *Dentalium* shells. The large chelae and the cephalothorax are deep red and the rest is straw-coloured in formalin.

Oedignathus inermis (Stimpson)

Range. Unalaska to Pacific Grove, California. Japan.

Size. ♀5 × 4–17 × 16 mm. ♂4 × 3.5–30 × 25 mm.

Local distribution.	Clayoquot Sound area,	2222–4,		1♂
		2222–6,	1♀	
	Nootka Sound area,	2231–14,		2♂
		2231–15,		1♂
		2231–30,	1♀	
		2231–32,	1♀	
	Esperanza Inlet area,	2241–12,		1♂
		2242–3,	1♀	
		2242–4,		1♂
	Queen Charlotte Islands,	3539,	8♀	7♂
		3540,		1♂

Remarks. The coloration, in formalin, is usually red-brown with violet granules on the large cheliped. The claws of the walking legs are black, with deep yellow bands on the distal part of the propodi.

Hapalogaster mertensii Brandt

Range. Atka, Aleutians, eastward and southward to Puget Sound.

Size. ♀10 × 11–17 × 19 mm. ♂15 × 16–22 × 24 mm.

Local distribution. Queen Charlotte Islands, 3521, 2♀ 2♂

Remarks. The absence of this species from the west coast of Vancouver Island, is perhaps significant, but no definite statement can be made without more extensive distribution records.

Cryptolithodes sitchensis Brandt

Range. Sitka, Alaska, to Pacific Grove, California.

Size. ♂7 × 10–36 × 52 mm.

Local distribution.	Clayoquot Sound area,	2223–3,	1♂
	Nootka Sound area,	2231–17,	1♂
	Esperanza Inlet area,	2242–4,	2♂

Remarks. One specimen in formalin is brick-red dorsally, and white, tan and red, ventrally; another pearl-grey with a symmetrical pattern of dark red dorsally and with the dorsal side of the chelipeds and legs tan; another a dirty white; and the fourth, grey etched with black, and periopods brown dorsally.

Lopholithodes foraminatus (Stimpson)

Range. Clayoquot Sound and Nanoose Bay, Vancouver Island, to San Diego, California.

Size. ♀ 110 × 130–120 × 140 mm.

Local distribution. Clayoquot Sound area, 2221–3, 3♀

Remarks. The northern limit for this species is usually given as Victoria, although Taylor (21) reports seeing it at Nanaimo. There are specimens from Nanoose Bay, north of Nanaimo, in the Museum of the Pacific Biological Station, Nanaimo, B.C.

Oregonia gracilis Dana

Range. Bering Sea to Monterey, California. Japan.

Size. ♀11 × 7–35 × 19 mm. ♂7 × 5–40 × 20 mm.

Local distribution.	Barkley Sound area,	2211–1,	2♀	1♂
	Clayoquot Sound area,	2221–3,		1♂
		2221–8,	10♀	8♂
		2221–16,	34♀	31♂
		2221–17,	11♀	19♂
		2221–20,	3♀	9♂
		2221–22,	1♀	2♂
		2221–26,	7♀	3♂
		2221–27,		1♂
		2221–28,	1♀	2♂
		2223–1,	1♀	
	Nootka Sound area,	2231–13,	3♀	
		2231–19,	2♀	2♂
		2231–29,	1♀	1♂
		2231–31,	5♀	1♂
		2231–34,	4♀	7♂
	Esperanza Inlet area,	2241–8,		1♂
		2242–6,		1♂
	Queen Charlotte Islands,	3519,		1♂
		3527,		1♂

Pugettia producta Randall

Range. Houston-Stewart Channel, Queen Charlotte Islands, to Santa Rosalia Bay, Lower California.

Size. ♀13 × 9–50 × 42 mm. ♂25 × 21–40 × 28 mm.

Local distribution.	Clayoquot Sound area,	2222–4,		1♂
	Nootka Sound area,	2231–28,	2♀	
		2231–32,		1♂
	Esperanza Inlet area,	2241–13,	1♀	
	Queen Charlotte Islands,	3521,		1♂

Remarks. This species has been previously recorded only from Vancouver Island southward.

Pugettia gracilis Dana

Range. Western extremity of the Aleutian Islands eastward and southward to Mendocino, California.

Size. ♀15 × 11–35 × 28 mm. ♂9 × 8–35 × 28 mm.

Local distribution.	Clayoquot Sound area,	2222–6,	1♀	
	Nootka Sound area,	2231–20,		2♂
		2231–28,		2♂
		2231–30,	1♀	
		2231–32,		1♂

	Esperanza Inlet area,	2241–11,		1♂
		2242–3,	1♀	1♂
		2242–4,	1♀	
	Queen Charlotte Islands,	3507,	5♀	1♂
		3521,	4♀	3♂
		3539,	3♀	5♂

Pugettia richii Dana

Range. Esperanza Inlet, Vancouver Island, B.C., to San Diego, California.

Size. ♀9 × 6–33 × 26.5 mm. ♂9.5 × 7–44 × 36 mm.

Local distribution.	Clayoquot Sound area,	2223–1,		1♂
		2223–3,		2♂
	Nootka Sound area,	2231–14,	1♀	1♂
		2231–17,		1♂
		2231–20,	1♀	1♂
		2231–28,	3♀	5♂
		2231–30,	3♀	
	Esperanza Inlet area,	2241–11,		1♂
		2241–12,	1♀	1♂
		2242–3,	6♀	3♂
		2242–4,	1♀	1♂
		2242–5,		1♂

Remarks. The northern limit of range of this species is extended by the present collection. There is considerable variation in colour, from red to brown, and the legs are usually banded with light and dark colour. A number of the specimens are covered with encrustations of bryozoans, hydroids, algae, etc.

Mimulus foliatus Stimpson

Range. Unalaska to Monterey Bay, California. Mexico.

Size. ♀11 × 11.5–23 × 24.5 mm. ♂11 × 10–35 × 39 mm.

Local distribution.	Clayoquot Sound area,	2223–1,		1♂
		2223–3,		1♂
	Nootka Sound area,	2231–20,		3♂
		2231–28,		1♂
		2231–30,	2♀	2♂
	Esperanza Inlet area,	2241–12,	1♀	1♂
		2242–3,	1♀	1♂
		2242–4,	2♀	3♂
		2242–5,		1♂
	Queen Charlotte Islands,	3507,		1♂
		3521,	1♀	

Remarks. There is considerable variation in the coloration, but the presence of a distinct V on the carapace seems to be fairly consistent. There are light coloured bands between the hepatic and lateral spines, which join

medially over the cardiac region. The predominant colour is red or red-brown, with a white V and red and white striped legs. The chelae are lighter in colour than the carapace.

Scyra acutifrons Dana

Range. Kodiak, Alaska, to San Diego, California.

Size. ♀13 × 9.5–36 × 26 mm. ♂10 × 8–46 × 35 mm.

Local distribution.	Nootka Sound area,	2231–16,	1♀	
		2231–20,	1♀	3♂
		2231–28,	3♀	1♂
		2231–29,	1♀	
		2231–30,	4♀	1♂
		2231–32,		1♂
	Esperanza Inlet area,	2241–12,	2♀	2♂
		2242–3,	4♀	
		2242–4,	3♀	7♂
		2242–5,	2♀	
	Queen Charlotte Islands,	3537,		1♂

Remarks. The carapace of the larger specimens is usually covered with an encrustation of sponges, tunicates, barnacles, etc. The tubercles are rose-coloured, and the legs banded with red and white.

Chorilia longipes Dana

Range. Shumagin Bank and Kodiak, Alaska, to San Diego, California. Japan.

Size. ♀8 × 4.5–34×20 mm. ♂7 × 4–21 × 11 mm.

Local distribution.	Clayoquot Sound area,	2221–16,	5♀	
		2221–17,	3♀	2♂
	Nootka Sound area,	2231–31,	1♀	
	Queen Charlotte Islands,	3526,		1♂
		3527,	2♀	1♂

Hyas lyratus Dana

Range. Bering Sea to Admiralty Inlet, Washington.

Size. ♀13 × 8.5 mm.

Local distribution.	Nootka Sound area,	2231–31,	1♀

Cancer productus Randall

Range. Kodiak, Alaska, to Laguna Beach, California.

Size. ♀37 × 57–55 × 85 mm. ♂10 × 11–27 × 42 mm.

Local distribution.	Clayoquot Sound area,	2222–4,		1♂
		2223–1,		1♂
		2223–3,		1♂
	Nootka Sound area,	2231–30,	1♀	
		2231–32,		1♂

	Esperanza Inlet area,	2241–13,	1 ♀	
		2242–3,		1 ♂
		2242–4,	1 ♀	

Remarks. The usual variety of colour in the small specimens is found: pure white; bands of brown and white; stripes of red and white; brown striped. The larger specimens are a uniform red.

Cancer magister Dana

Range. Unalaska to Monterey Bay, California.

Size. ♀ 35 × 50 mm. megalopae.

Local distribution.	Clayoquot Sound area,	2222–4,	1 ♀
	Nootka Sound area,	2231–28,	2 megalopae
	Esperanza Inlet area,	2241–9,	2 megalopae

Cancer branneri Rathbun

Range. Granite Cove, Port Althorp, Alaska, to Santa Catalina Island, California.

Size. ♀ 13 × 17–28 × 39 mm. ♂ 4.5 × 5.5–35 × 54 mm.

Local distribution.	Barkley Sound area,	2211–1,	2 ♀	
	Clayoquot Sound area,	2221–17,		1 ♂
		2221–20,	2 ♀	3 ♂
		2221–26,	12 ♀	7 ♂
		2221–27,	1 ♀	2 ♂
	Esperanza Inlet area,	2241–8,		2 ♂

Cancer oregonensis (Dana)

Range. Pribilof Island and Rat Island, Alaska, to Santa Barbara, California.

Size. ♀ 10 × 14–17 × 21.5 mm. ♂ 4.5 × 5–9.5 × 12 mm.

Local distribution.	Clayoquot Sound area,	2221–25,	1 ♀	
		2222–6,	1 ♀	
	Nootka Sound area,	2231–14,		1 ♂
	Esperanza Inlet area,	2241–13,	1 ♀	
		2242–3,		2 ♂
		2242–4,		3 young

Telmessus cheiragonus (Tilesius)

Range. Bering Sea to California.

Size. ♂ 7 × 7 mm.

Local distribution.	Queen Charlotte Islands,	3536,	1 ♂

Lophopanopeus bellus (Stimpson)

Range. Prince William Sound, Alaska, to Monterey, California.

Size. ♀ 8 × 11–15 × 22 mm. ♂ 13 × 19–20.5 × 30 mm.

Local distribution.	Nootka Sound area,	2231–20,	1 ♀	1 ♂
		2231–29,		2 ♂
		2231–30,	6 ♀	
	Esperanza Inlet area,	2241–12,		1 ♂
		2241–13,		1 ♂
		2242–3,	2 ♀	1 ♂
	Queen Charlotte Islands,	3507,		1 ♂

Pinnixa faba (Dana)

Range. Prince of Wales Island, Alaska, to Humboldt Bay, California.

Size. ♀5 × 9 mm. ♂6.5 × 11 mm.

Local distribution.	Nootka Sound area,	2231–14,		1 ♂
	Esperanza Inlet area,	2242–6,	1 ♀	

Remarks. The male is tan with a white mottled branchial region and the female is white, mottled with brown.

Pinnixa littoralis Holmes

Range. Sitka, Alaska, to San Diego, California.

Size. ♀ 11.5 × 18.5–16 × 20 mm.

Local distribution.	Esperanza Inlet area,	2242–3,	1 ♀
	Queen Charlotte Islands,	3532,	1 ♀

Remarks. The "liver" shows yellow and the ovary orange through the transparent carapace.

Pinnixa occidentalis Rathbun

Range. Unalaska to Magdalena Bay, Lower California.

Size. ♀2 × 4–2.5 × 5 mm. ♂2 × 5–3 × 6.5 mm.

Local distribution. Queen Charlotte Islands, 3513, 12 ♀ 9 ♂

Pinnixa schmitti Rathbun

Range. Port Levasheff, Alaska, to San Francisco Bay, California.

Size. ♀2.5 × 4.5 mm. ♂2.5 × 5 mm.

Local distribution. Esperanza Inlet area, 2242–6, 1 ♀ 1 ♂

Scleroplax granulata Rathbun

Range. Esperanza Inlet and Departure Bay, Vancouver Island, B.C., to Ensenada, Lower California.

Size. ♀4.5 × 6–5 × 6 mm.

Local distribution. Esperanza Inlet, 2242–6, 3 ♀

Of the 44 species in the collection, two, *Pachycheles pubescens* Holmes and *Pagurus confragosus* (Benedict), have not been previously recorded from British Columbia. Five species found in the Queen Charlotte Islands collec-

tion are not represented in the Vancouver Island collection, but as all of these range southward, it is probable that they occur here also. *Hemigrapsus nudus* (Dana) and *H. oregonensis* (Dana), the common shore crabs, do not occur in the west coast of Vancouver Island collection. Two explanations may be advanced: First, both species require the protection of gravel or loose rocks, which condition apparently is not commonly met with on that rugged, surf-washed shore; and second, at low tide the shore crabs are sufficiently high up on the beach to be entirely missed when collections are made near low water line. That these species do occur in this region there can be little doubt, as the larvae were present in the zooplankton taken from the same area. Moreover, Spencer (18) reports them abundant throughout Clayoquot Sound. Fraser did not collect these two species but identified them in the field at a number of Queen Charlotte Islands shore stations. He also identified, but did not collect, *Cancer magister* Dana, *C. productus* Randall, and *C. oregonensis* (Dana).

Table II is a compilation of the records of the 69 species of reptant Decapoda that have been found in British Columbia. The coast has been divided into eight regions: southern Vancouver Island (Victoria, B.C., and Friday Harbour, Washington); the east coast of Vancouver Island and the corresponding mainland coast; four areas on the west coast of Vancouver Island; the Queen Charlotte Islands; Queen Charlotte Sound, and northeast coasts. Records from published works are indicated by *p*, unpublished personal records by *H* and the present collection by *X*.

TABLE II

OCCURRENCE OF REPTANT DECAPODA IN BRITISH COLUMBIA

	Gulf of Georgia	Victoria, B.C., and Friday Hbr., Washington	Barkley Sound	Clayoquot Sound	Nootka Sound	Esperanza Inlet	Queen Charlotte Islands	Queen Charlotte Sound and north
Munida quadrispina Benedict	*p*	*p*	*X*		*X*		*Xp*	*p*
Petrolisthes eriomerus Stimpson	*p*	*p*		*X*	*X*	*X*	*X*	
Petrolisthes cinctipes (Randall)				*Xp*	*X*	*X*	*X*	
Pachycheles rudis Stimpson		*p*	*p*	*Xp*	*X*	*X*		
Pachycheles pubescens Holmes						*X*		
Upogebia pugettensis (Dana)	*p*	*p*		*p*		*X*	*Xp*	
Callianassa californiensis Dana	*p*	*p*		*p*				
Callianassa gigas Dana		*p*						
Pagurus alaskensis (Benedict)	*p*	*p*		*X*	*X*	*X*		
Pagurus aleuticus (Benedict)	*p*	*p*			*X*			*p*
Pagurus ochotensis Brandt	*p*	*p*	*Xp*	*X*	*X*	*X*	*X*	
Pagurus brandti (Benedict)	*H*	*p*					*X*	*p*
Pagurus dalli (Benedict)	*p*	*p*		*X*	*X*			
Pagurus confragosus (Benedict)					*X*			
Pagurus cornutus (Benedict)								*p*
Pagurus gilli (Benedict)	*H*	*p*						
Pagurus beringanus (Benedict)	*p*	*p*		*X*			*X*	
Pagurus kennerlyi (Stimpson)	*p*	*p*	*X*	*X*				
Pagurus setosus (Benedict)	*p*	*p*		*X*	*X*		*X*	
Pagurus hirsutiusculus (Dana)	*p*	*p*		*X*	*X*	*X*	*X*	

TABLE II—*Concluded*

OCCURRENCE OF REPTANT DECAPODA IN BRITISH COLUMBIA—*Concluded*

	Gulf of Georgia	Victoria, B.C., and Friday Hbr., Washington	Barkley Sound	Clayoquot Sound	Nootka Sound	Esperanza Inlet	Queen Charlotte Islands	Queen Charlotte Sound and north
Pagurus granosimanus (Stimpson)	*p*	*p*		*X*	*X*		*X*	*p*
Pagurus hemphillii (Benedict)			*p*		*X*	*X*	*X*	
Pagurus tenuimanus (Dana)	*H*	*p*						*p*
Pagurus splendescens Owen	*p*	*p*						
Paguristes turgidus (Stimpson)	*p*	*p*	*X*	*X*	*X*		*X*	*p*
Parapagurus mertensii (Brandt)					*p*			
Orthopagurus minimus (Holmes)							*Xp*	
Orthopagurus schmitti (Stevens)	*p*	*p*	*X*			*X*		
Hapalogaster mertensii Brandt	*H*	*p*					*X*	
Oedignathus inermis (Stimpson)				*X*	*X*	*X*	*Xp*	
Acantholithodes hispidus (Stimpson)	*p*	*p*					*p*	
Placetron wosnessenskii Schalfeew		*p*					*p*	
Cryptolithodes sitchensis Brandt		*p*		*X*	*Xp*	*X*	*p*	
Cryptolithodes typicus Brandt	*p*	*p*						*p*
Lopholithodes foraminatus (Stimpson)	*p*	*p*		*X*				
Lopholithodes mandtii Brandt	*p*	*p*	*p*					
Rhinolithodes wosnessenskii Brandt		*p*						*p*
Paralithodes rostrofalcatus McKay								*p*
Paralithodes camtschatica Tilesius							*p*	
Paralomis multispina (Benedict)							*p*	
Phyllolithodes papillosus Brandt	*p*	*p*						
Oregonia gracilis Dana	*p*	*p*	*X*	*Xp*	*X*	*X*	*Xp*	*p*
Pugettia producta Randall	*p*	*p*	*p*	*Xp*	*X*	*X*	*X*	*p*
Pugettia gracilis Dana	*p*	*p*	*p*	*Xp*	*X*	*X*	*Xp*	*p*
Pugettia richii Dana		*p*	*p*	*Xp*	*X*	*X*		
Mimulus foliatus Stimpson			*p*	*Xp*	*X*	*X*	*X*	
Scyra acutifrons Dana	*p*	*p*	*p*		*X*	*X*	*Xp*	*p*
Chorilia longipes Dana	*p*	*p*		*X*	*X*		*X*	*p*
Chionoecetes bairdi Rathbun	*p*							*p*
Chionoecetes angulatus Rathbun							*p*	
Hyas lyratus Dana	*p*	*p*		*p*	*X*			*p*
Telmessus cheiragonus (Tilesius)	*p*	*p*		*p*			*Xp*	*p*
Cancer productus Randall	*p*	*p*	*p*	*Xp*	*X*	*X*	*p*	*p*
Cancer branneri Rathbun	*H*		*Xp*	*X*		*X*		
Cancer gracilis Dana	*p*	*p*		*p*				
Cancer magister Dana	*p*	*p*		*Xp*	*X*	*X*	*p*	*p*
Cancer oregonensis (Dana)	*p*	*p*		*X*	*X*	*X*	*p*	*p*
Lophopanopeus bellus (Stimpson)	*p*	*p*		*p*	*X*	*X*	*X*	
Pinnotheres pugettensis Holmes	*p*	*p*						
Pinnotheres taylori Rathbun	*p*		*p*					
Fabia subquadrata Dana	*p*	*p*					*p*	
Pinnixa faba (Dana)	*p*	*p*		*p*	*X*	*X*		
Pinnixa littoralis Holmes	*p*	*p*	*p*			*X*	*X*	
Pinnixa occidentalis Rathbun	*p*						*X*	*p*
Pinnixa schmitti Rathbun	*H*	*p*				*X*		
Pinnixa tubicola Holmes	*p*	*p*						*p*
Scleroplax granulata Rathbun	*p*	*p*				*X*		
Hemigrapsus nudus (Dana)	*p*	*p*		*p*				*p*
Hemigrapsus oregonensis (Dana)	*p*	*p*		*p*				*p*

p — previously recorded; H — in author's collection; X — in 1934 and 1935 collections.

It is only the shore and shallow water forms that one would expect to be appreciably influenced by the different conditions found on the exposed west coast as compared with the sheltered waters of the Gulf of Georgia, which borders the east coast. Of these conditions the temperature of the water is probably the chief limiting factor, as was suggested for the difference in littoral distribution of *Pagurus beringanus* (6). The surface water temperatures of the west and south coasts of Vancouver Island are consistently lower than those of the Gulf of Georgia. As a result, at Victoria, this species may be collected at low tide, while to obtain specimens of a similar size at Nanaimo it is necessary to dredge in deeper water.

Of the 69 species recorded from British Columbia, 63 have been found in the waters surrounding Vancouver Island. More than half of these may be obtained at low tide. The remainder are normally taken only by dredging and thus are often rather poorly represented in collections. Two of these species, *Chionoecetes bairdi* Rathbun and *Pinnixa occidentalis* Rathbun, have been found only on the east coast of Vancouver Island, while four others, *Pagurus confragosus* (Benedict), *Parapagurus mertensii* (Brandt), *Placetron wosnessenskii* Schalfeew, and *Rhinolithodes wosnessenskii* Brandt have been found only on the south or west coasts. Since none of these species has been taken in large numbers, or often, the range will probably be extended by future collecting. Nine shore and shallow water forms have been found only on the south or west coasts. Of these, *Callianassa gigas* Dana and *Pachycheles pubescens* Holmes have been rarely taken, but *Petrolisthes cinctipes* (Randall), *Pachycheles rudis* Stimpson, *Pagurus hemphillii* (Benedict), *Oedignathus inermis* (Stimpson), *Cryptolithodes sitchensis* Brandt, *Pugettia richii* Dana, and *Mimulus foliatus* Stimpson seem to be fairly abundant on the west coast of Vancouver Island, and thus would appear to require the cold waters and rugged conditions associated with proximity to the open ocean.

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APOPHALLUS IMPERATOR SP. NOV., A HETEROPHYID ENCYSTED IN TROUT, WITH A CONTRIBUTION TO ITS LIFE HISTORY[1]

BY L. L. LYSTER[2]

Abstract

Apophallus imperator sp. nov., (Heterophyidae : Trematoda) is described and figured. It is a potential human parasite of which the metacercarial stage is encysted in *Salvelinus fontinalis* in the Province of Quebec. The other hosts are unknown; experimentally, it becomes adult in cats and pigeons. The significance of the genus *Apophallus* and related genera is reviewed and the systematics of *Apophallus* discussed. Organization of the gonotyl is the only feature accepted as uniformly distinctive of this genus and modifications in that structure are traced and recommended for their significance in specific diagnoses.

Introduction

In the course of a survey of parasitism in trout during the summer of 1938, an interesting condition was reported among Speckled Trout *(Salvelinus fontinalis)* taken from parts of Lake St. Bernard in the Province of Quebec. The fins and the skin under the scales in a specimen sent from this area were disfigured by numerous black spots. Microscopic examination showed that this was caused by the encysted metacercaria of some trematode. To establish the identity of the parasite, part of the trout was given to a cat that had never previously been fed fish. On post-mortem examination of the cat 12 days later, several minute flukes, easily recognizable as members of the family Heterophyidae, were recovered.

Recent studies have illustrated the economic interest of the Heterophyidae. The lack of host specificity among many genera of the family makes it important to fur-bearing animals and wild life as well as to man. Human heterophyidiasis has been known for many years, and Africa, Garcia, and de Leon in the Philippines have demonstrated a potential high pathogenicity in human infections (2, 4). Not only is the intestinal mucosa parasitized but the eggs of the parasite may be carried by the blood stream to the heart and the central nervous system with serious effects. Cameron (8) recently recovered unidentified heterophyid eggs from a patient in a local hospital, the first recorded human case in North America.

Various marine and freshwater fish are known to be heterophyid vectors. One of the carriers of *Metagonimus* in Japan is a salmonid fish, but no infection in North American species of these fish has been reported.

Trout carrying the metacercariae were easily obtained from the southern end of Lake Commandant, Argenteuil Co., Quebec. The condition has been

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known to exist there for several years and all experimental material came from there.

Description (Fig. 1)

Body linguiform, pyriform, or discoid, covered with spines in parallel rows, most numerous from oral sucker to intestinal bifurcation, very few posterior to testes and none at extreme anterior tip. Oral sucker subterminal, 0.063 by 0.056 mm. Pre-pharynx very short, usually entirely hidden behind the oral sucker. Pharynx longitudinally ovoid. Oesophagus long, weak, extending for one-half length of body, or somewhat less. Caeca larger than oesophagus, extending to well behind testes. Acetabulum relatively well developed and large, 0.077 by 0.070 mm., medial and posterior to intestinal furcation. Genital sinus opening anterior to ventral sucker; two gonotyls dorsal and anterior to acetabulum, 0.021 by 0.027 mm., narrowly separated. Seminal vesicle large structure dorsal and posterior to acetabulum in midline, curving ventrally and laterally, narrower terminal portion; dorsal and lateral portions sac-like and separated by constrictions. Ovary pyriform, 0.026 to 0.031 mm. by 0.056 to 0.077 mm., on left side of body nearer to ventral sucker than to testes. Seminal receptacle large, globular, anterior to ovary. Testes two, 0.057 to 0.063 mm. by 0.112 to 0.126 mm., triangular in shape, usually oblique but sometimes almost side by side, or almost tandem; right member anterior; posterior member removed from end by about its own diameter. Vasa efferentia continue in vas deferens to join seminal vesicle left of acetabulum. Uterus short, few turns. contains 5 to 20 large brown eggs, 0.014 to 0.019 mm. by 0.033 to 0.035 mm., reaches genital opening from left side of acetabulum. Common vitelline ducts rise at level of anterior testis. Vitellaria rise at level of gonotyl, extend to posterior end in a narrow limited band of scattered follicles, extending towards median field immediately behind testes and at level of common vitelline duct, but rarely meeting. Excretory bladder S-shaped with arms to pharyngeal area.

Variations in Morphology

All adult specimens were treated in the same way. The intestinal mucosa of the experimental animal was scraped into saline and sedimented with the addition of a little sodium bicarbonate. The living flukes were pipetted into cold fixative (glacial acetic formalin alcohol) and shaken. They were preserved in a mixture of 5% glycerine in 70% alcohol, to which had been added 5% formalin, then washed in distilled water and dilute alcohol and stained in acid alum carmine. In spite of this, there is a wide range of body shape (Figs. 4–7). Those from the pigeon are more uniformly pyriform, those from the cat usually ovoid, constricted in the region of the ventral sucker.

Two specimens show vitellaria extending anteriorly as far as the bifurcation of the oesophagus. In all others, the vitellaria are restricted to an area behind the gonotyl. In one of the two variant specimens the ventral sucker has been displaced antero-laterally and lies up the right side of the body near

the base of the oesophagus. In both, the testes are almost tandem and removed posteriorly. The status of these forms is difficult to determine. Important features have been obscured in mounting; one might well be *Apophallus venustus* but the other seems definitely a malformation of the present species.

Identification

This form, obviously a heterophyid, is also recognizable as a member of the genus *Apophallus sensu latu*. This group is poorly understood. In order that identification may be clear some discussion of the related genera that include *Apophallus* is necessary here. It is limited as far as possible to *Apophallus* and the genera that have been confused with it.

History

The genus *Apophallus* was created in 1909 by Luhe (18) with *Distomum muhlingi* Jagerskiold, 1899, from *Larus ridibundus* as type species; it was incorrectly described as *Distomum lingua* by Creplin in 1898.

In 1919 Skrjabin and Lindtrop (23) erected the genus *Rossicotrema* with *R. donicum* as type species, from the cat and dog, distinguishing it from *Apophallus* because of the condition of the vitellaria and testes.

Without reference to that genus, Ransom in America created the genus *Cotylophallus* in 1920 (22) based on the arrangement of the vitellaria; it contained two species, *C. venustus* from the cat, dog, and wolf, and *C. similis* from *Phoca vitulina*, those also being distinguished by vitellaria arrangement. In the same paper he described *A. brevis* from *Larus delawarensis*.

All subsequent authors have treated *Cotylophallus* as a synonym of *Rossicotrema*.

In 1924, Szidat (25) described *Apophallus major* from *Larus fuscus*, basing his new species only on absolute measurements.

In 1931, Price (20) described *A. crami* from *Larus californicus*, in which the vitellaria were limited to the post-ovarian region. A year later (21) he created *A. zalophi* from *Zalophus californicus*, differing widely from the type in organization of the vitellaria, development of the pre-pharynx and other details. The species *A. americanus* was described on two immature specimens from the stomach of fish in 1932 by Van Cleave and Mueller (27). The specimens were apparently ectopic forms and the specific identification is based on features now known to be variable. The species *americanus* may well be valid, but in reporting it the authors imply that they are creating it largely to avoid confusion until further material is available.

In 1935, Africa (3) described the species *eccentricus* which he referred to *Apophallus*, though it differed in several details usually considered supergeneric and mainly in the position of the gonotyl.

Thus, two closely related genera, *Apophallus* and *Rossicotrema*, containing nine species between them, have been introduced into the literature. These Ciurea (9) placed together in his sub-family Apophallinae, because of common

characters of the acetabulo-genital complex (notably that the genital sinus opens anterior to the acetabulum).

Witenberg (28), reviewing the family, placed *Apophallus* and *Rossicotrema* together with *Cryptocotyle* and *Tocotrema* (in which the genital sinus opens posterior to the acetabulum) in the new tribe *Cryptocotylea*, and in the sub-family Heterophyinae which included the sub-families Metagoniminae, Apophallinae, and Cryptocylinae as understood by Ciurea. He considered the arrangement of the acetabulo-genital complex of sub-generic importance and differentiated the tribe solely on the anterior extent of the vitellaria. This division would remove *A. crami*, in spite of its very obvious relationships, to his tribe Heterophyea, where there is no genus to accommodate it. Witenberg refused to accept comparison of vitellarian fields for separating species. He reduced *R. donicum*, *R.* (*-Cotylophallus*) *similis* and *R.* (*-Cotylophallus*) *venustum* to synonymity, and transferred *A. brevis* to this genus, making it a synonym of *R. donicum*. He discounted the specific importance of size and made *A. major* a synonym of *A. muhlingi*.

In 1930 (29), in amending his previous monograph in several details, he made the genus *Rossicotrema* a synonym of *Tocotrema* Looss, 1899. He considered the condition and position of the acetabulum and position and number of gonotyls of specific interest only. Stunkard (24), in describing the life history of the type species, *Tocotrema lingua*, did much to establish its congenerity with *Cryptocotyle* Luhe, 1899, a relationship that had previously been accepted by all workers with two exceptions (Ciurea (10) and Linton (16)).

Price (20), in 1931, considered that the acetabulo-genital complex furnished generic characters. Thus, he regarded *Rossicotrema* as distinct from *Tocotrema* (and, therefore, from *Cryptocotyle*) but indistinguishable from *Apophallus*. In the last genus he recognized *muhlingi*, *crami*, *donicus* (= *venustus* and *similis*), and *brevis*, as valid species, all separable on features of the vitellaria. Ciurea (10) did not agree that *Apophallus* and *Rossicotrema* could be synonyms, because of variations in body shape, arrangement of testes, and development of metacercariae. He concurred, however, in the differentiation of *Tocotrema* and *Rossicotrema*, which he assigned to the sub-families Cryptocotylinae and Apophallinae respectively.

The sub-family Cryptocotylinae had been created by Luhe (18), 1909, to contain the genera Cryptocotyle and *Scaphanocephalus*. To these Ciurea added the genera *Tocotrema* and *Ciureana*. The sub-family is characterized mainly by the reduced condition of the acetabulum and genital sucker and the position of the genital opening posterior to the acetabulum.

The sub-family Apophallinae, created by Ciurea (9), is based on the extent of development of the genital sucker and acetabulum and the position of the genital opening, anterior to the acetabulum. He has placed the genera *Apophallus*, *Rossicotrema*, *Euryhelmis*, and *Pricetrema* in it. The genus *Pricetrema* was erected at this time by Ciurea to accommodate *A. zalophi* Price, 1931. It is separated because of the length of the oesophagus, the situation of the testes, and the course of the seminal vesicle and uterus.

Poche (19) created the genus *Euryhelmis* to include *Distomum squamula* Rudolphi, 1819, but incompletely described it. Recently Baer (6), 1931, has made a more definite contribution to our knowledge of the morphology of this form. He points out the unique organization of the acetabulo-genital complex. The genital sucker, situated anterior to the acetabulum, consists of a *single* papillae-like muscular structure attached anteriorly. Very recently a description and life history of a new species, *Euryhelmis monorchis*, has been published by Ameel (5). In spite of its single testis, he placed it in the sub-family Heterophyinae *sensu* Witenberg, but his observations refute rather more than support the inclusion of this genus with *Apophallus* in the restricted sub-family Apophallinae *sensu* Ciurea.

Cameron (7) in a discussion on the family in 1936 accepted the synonymity of *Apophallus* and *Rossicotrema* but discounted the importance of body shape and size as a diagnostic character. He accorded only limited value to testicular arrangement for separating species but he acknowledged the importance of the vitellarian field. By this criterion he was able to distinguish *A. venustus* from *A. donicus*, *muhlingi*, and *brevis*, but not from *A. similis*, which he concluded to be a synonym.

It is apparent from this brief review that a great deal of confusion has resulted in these genera because of lack of agreement as to what should constitute generic and specific features.

The Genus

The genus *Apophallus* has previously been recorded under various synonyms. Price and Cameron consider *Rossicotrema* synonymous with it. *Rossicotrema* has been accepted as synonymous with *Cotylophallus*, and Witenberg considered it as a synonym of *Cryptocotyle* by various workers. *Pricetrema* was created by Ciurea to accommodate a species originally placed in *Apophallus*.

Some convention must be accepted to facilitate classification of this group. The obvious variation in the associated genera under discussion is in the structure of the acetabulo-genital complex. This feature has been variously considered of specific, generic, and super-generic significance.

Should the specific valuation be accepted, as recommended by Witenberg (28), a confusing group of synonymous designations results. No logical series of generic and specific characteristics can be traced. The variation in the complex seems to divide this part of the family into two distinct groups as represented by the genera *Cryptocotyle* and *Apophallus*. In the first a *single* gonotyl guards the genital opening *posterior* to the acetabulum. In the second, a *pair* of gonotyls guards the genital opening *anterior* to the acetabulum.

At the moment it is difficult to evaluate fully the true significance of this division, whether generic or super-generic. Two complementary factors must be considered:

1. The position of the genital opening.
2. The number of gonotyls.

The species *A. eccentricus* is unique because of the lateral opening of its genital pore. If valid, this species may represent a series of undiscovered forms which would be intermediate between the two genera and make *Apophallus* a synonym of *Cryptocotyle*. However, re-study will probably illustrate its closer relationship to *Stictodora* than to *Apophallus*.

A single gonotyl seems a constant feature among the genera in which the genital opening is posterior. With two exceptions all species with the anterior genital opening have two gonotyls. These exceptions, *Euryhelmis squamula* and *E. monorchis*, are of poorly understood phylogeny. They may represent a parallel organization which would place *Euryhelmis* in the same subfamily as *Apophallus* (as Ciurea (10) has done); they may be a continuation of the *Apophallus* type of development and therefore be congeneric with it; or, as available evidence suggests, they may have developed distinctly from *Apophallus* and thus bear no relationship to this genus. Present evidence, then, does not support super-generic or specific evaluations of these major features of differentiation, although in theory either may be correct. Following Price (20) and Cameron (7), generic rank of this character seems most practicable.

Genus *Cryptocotyle*

Reduced acetabulum, single gonotyl, posterior genital opening.

This genus is of no further interest in the present discussion.

Genus *Apophallus* (= *Pricetrema*, *Cotylophallus*, and *Rossicotrema* (not synonymous with *Tocotrema*).

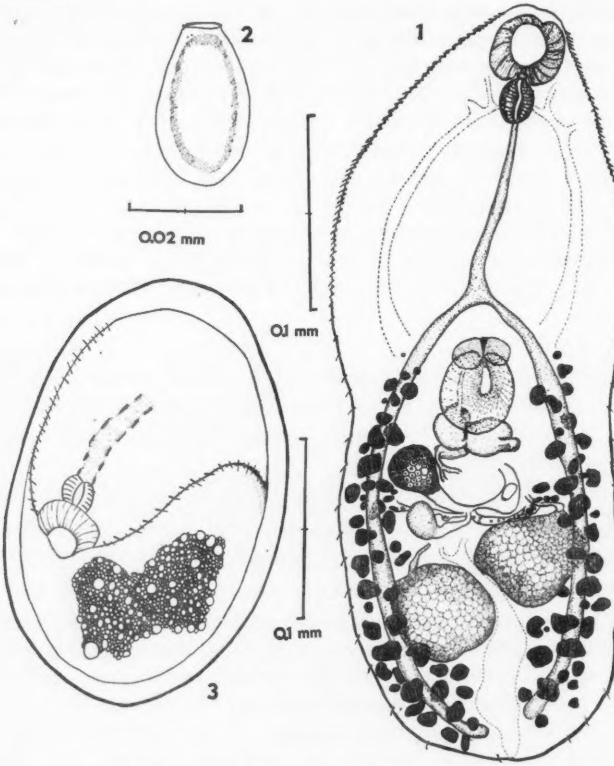
More distinct acetabulum, paired gonotyls, anterior genital opening.

This genus is essentially the same as Ciurea's sub-family Apophallinae, with the exclusion of the genus *Euryhelmis*. The present species is assigned to it.

The Species

Less clearly indicated are the specific characters; Ciurea, Africa, and Cameron and the present paper have proved the inconstancy of shape and size. The relative position of testes is variable within some species, more constant in others, but never suitable as a specific feature. Many authors have accepted the extent and arrangement of the vitellaria for diagnosing species. By this feature *A. venustus*, in which the vitellaria reach the crural furcation, is separable from *A. donicus* and *A. brevis*, in which the follicles do not exceed the gonotyls. In studying *A. donicus* (from the collection of Dr. Ciurea) and *A. brevis* (from the collection of Dr. Cameron) I find that the anterior limit of the vitellaria is constant but does not provide differences for complete differentiation of these species. From the same material it is seen that there is considerable variation in the medial follicles within each species. In *A. brevis*, the vitellaria meet behind the testes, but in front of these organs they are usually limited to the lateral fields. In a few specimens, however, they almost meet anterior to the ventral sucker. In *A. donicus*, the same condition may be noted, but in reverse order. The vitellaria usually meet in the midline anterior to the ventral sucker, but in a few specimens they

are limited to the lateral fields in this area. (Cameron's statement that the vitellaria did *not* reach "the ventral sucker" in these forms is probably a *lapsus*, intended for "the intestinal bifurcation".) These variations demonstrate the fact that the arrangement of the vitellaria is not acceptable for identifying species when considered alone. Further less variable characters must be found.

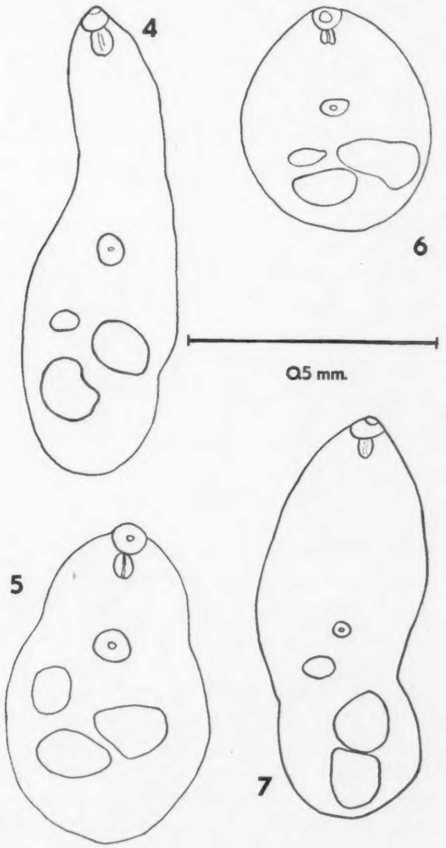


FIGS. 1–3. *Apophallus imperator sp. nov.* FIG. 1. *Adult from experimental cat.* FIG. 2. *Eggs from faeces of same host.* FIG. 3. *Encysted metacercaria from trout.*

Absolute measurements have not been accepted, but comparative measurements and morphology, especially of the more heavily muscled structures, should be valuable. The more strongly organized and least variable structures are the seminal vesicle, the oral sucker, and the acetabulo-genital complex. Of these, modification in the seminal vesicle is seen upon study to be a superspecific factor, and the oral sucker is important when considered in comparison with the ventral sucker, but does not afford a complete range of variations. Of the three, the acetabulo-genital complex seems likely to be the most satisfactory structure upon which to base criteria. The genital

sucker is most subject to the evolutionary changes that characterize the family to the extent that it has been assigned a special term "gonotyl." The genus, too, is identified by the condition of the remnant of this organ. Each species then might show a distinct development of the important structure.

The acetabulo-genital complex was studied in the three species of the genus *Apophallus* that have been confused in North American reports, *donicus*, *venustus*, and *brevis*, and in the present form and found to be separable. In *A. venustus* the ventral sucker is strongest; anterior to it is the genital structure, weakly muscled but illustrating distinctly its affinity to the true genital sucker of other trematodes, and lacking the extensive papillae-like construction of the organ as found in the other species of the genus (Fig. 8).



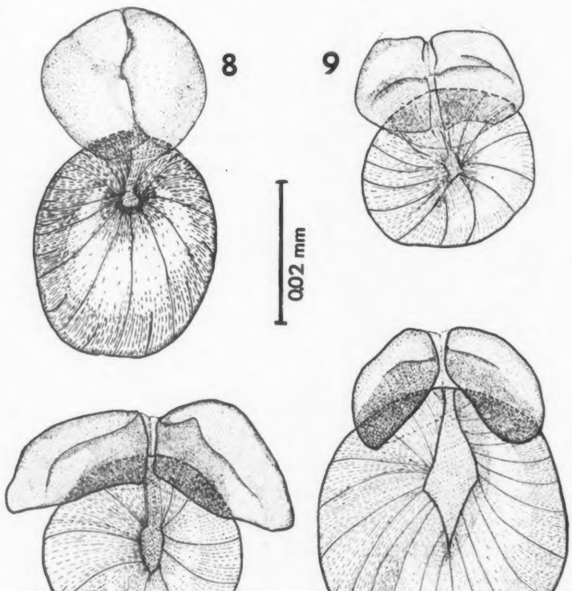
FIGS. 4 – 7. *Apophallus imperator sp. nov.* FIGS. 4 AND 5. *Outlines of adults from pigeon.* FIGS. 6 AND 7. *Outlines of adults from cat.*

In the remaining species the ventral sucker is less strongly muscled, and the genital structure is less weak. In *A. donicus* the papilla-like development is also somewhat limited, but not to the same extent as in *A. venustus* (Fig. 9). In *A. brevis* and the present form the structure consists of two distinct and strong bodies with little apparent relation to a primitive sucker. In the former species these gonotyls are large and extend laterally well beyond the acetabulum (Fig. 10), while in the latter they are roughly unilateral with this organ (Fig. 11).

Thus, two types of variable development are found in the remnant of the genital sucker in these species:

1. Papillae-like, far removed from progenital type—
   brevis—gonotyls large, extend laterally beyond margin of acetabulum.
   present species—gonotyls not so large, do not extend past lateral margins.
2. Not papillae-like, showing affinity to true genital sucker—
   venustus—gonotyls compound globular structures.
   donicus—gonotyls closely associated but more distinct than in *venustus*.

The remaining species are already easily distinguishable, with the exception of *muhlingi*.



FIGS. 8 – 11. *Acetabulum and gonotyl of Apophallus spp.* FIG. 8. *A. venustus.* FIG. 9. *A. donicus.* FIG. 10. *A. brevis.* FIG. 11. *A. imperator.*

A. muhlingi and the present form have some otherwise unique features in common. In each the vitellaria reach just to the level of the gonotyls and never extend medially except behind and between the testes. Similarly the acetabulum in each is usually slightly larger than the oral sucker. Though no specimens of *A. muhlingi* were available for comparison, Ciurea's careful discussion on it provides details for differentiation (10). The eggs in *A. muhlingi* are much broader than in the present form, though of approximately the same length. Of greater value is the nature of the gonotyls. He describes these organs as being symmetrical hemispheres with a diameter of 0.017 mm. His illustration shows a pair of such structures with the complete diameter parallel to the axis of the body. In the present form the gonotyls are 0.021 mm. in this measurement and 0.021 mm. transversely. Thus, the gonotyls of the two forms vary in size, shape, and direction of greatest measurement, though they are the most nearly alike of the species discussed.

Though it is closely related to *muhlingi* and *brevis*, the writer is thus able to distinguish this trout-carried member of the genus and considers it to represent a hitherto undescribed species, for which the designation *imperator* is proposed (from the locality in which it was discovered, Lake Commandant).

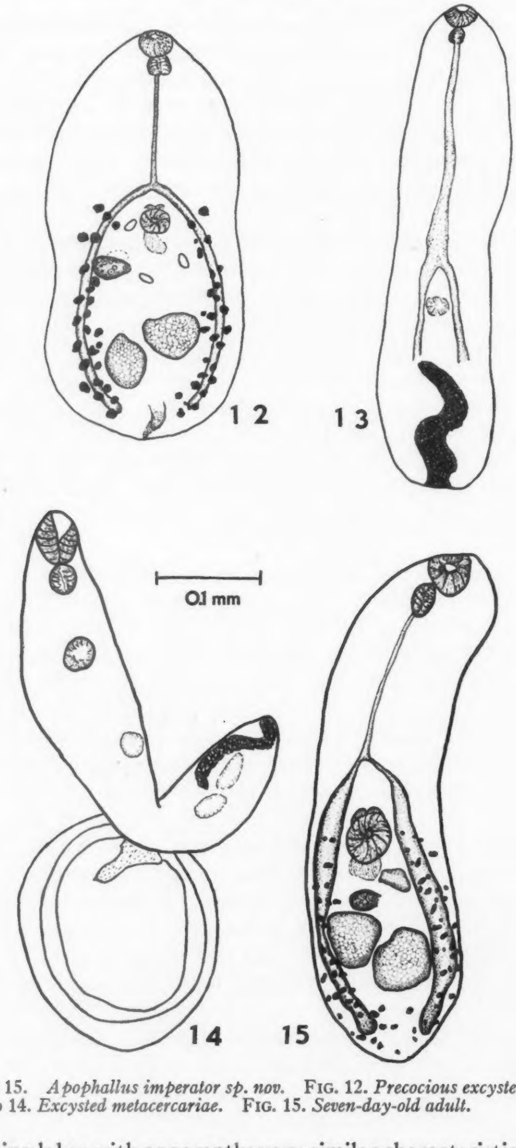
Metacercaria (Fig. 3)

The black pigmented cyst containing the metacercaria of *A. imperator* is easily seen in the trout. As in other members of the group, there is a primary cyst, hyaline and strong, within two outer layers. At least one of these is the host tissue surrounding the organism and is heavily pigmented. The primary cyst, 0.231 by 0.154 mm., is evenly oval in outline. The encysted metacercaria is folded upon itself and is very like the same form in the other heterophyids. The oral sucker, pharynx, traces of the oesophagus, and cuticular spines are distinguishable. The body contains many crystalline objects and others that resemble oil-droplets. The terminal area is filled with a mass of dark globules.

Efforts to cause excystment by artificial digestion failed with a single exception. This specimen probably represents a case of precocious development. All organs were present and there were three or four eggs in the uterus (Fig. 12). Other specimens freed by mechanical means never showed such advanced development. Rudimentary gonads, an S-shaped excretory sac filled with black material, and the faintly outlined acetabulum were usually present (Figs. 13 and 14).

The "black spots" occur on the ventral and lateral parts of the body on the skin just under the scales, and are frequent on the fins, tail, operculum, jaws, inside the mouth, on the gill bars, etc. (Table I). In only two fish, so heavily infected that they were almost uniformly black, were there cysts in the flesh, and even then only a few occurred. There seems to be no selected site for encystment such as Cameron found for *A. venustus* in the catfish.

In addition to Lakes Commandant and St. Bernard, infected trout have been reported from many lakes in the Commandant area. Curiously enough,



FIGS. 12 – 15. *Apophallus imperator sp. nov.* FIG. 12. *Precocious excysted metacercaria.* FIGS. 13 AND 14. *Excysted metacercariae.* FIG. 15. *Seven-day-old adult.*

of neighbouring lakes with apparently very similar characteristics and common outflow, observers have noticed that one will show infected trout and the other will be free. A small portion of trout skin sent by the Federal Department of Fisheries from a New Brunswick lake carried similar cysts. Hunter,

TABLE I

DISTRIBUTION OF HETEROPHYID BLACK SPOT IN TROUT

Body area	No. of cysts per sq. in.		
Base tail fin	54	43	34
Tail fin	61	116	10
Lateral line—dorsal fin	80	37	29
Dorsal fin	47	64	6
Pectoral fin	100	112	22
Base pectoral fin	80	50	21
Gill cover (external)	63	65	12
Gill cover (internal)		5	
Gill arch		4	3
Peduncle		10 (total)	7 (total)
Anal fin		50	7
Pelvic fin		40	10

These cysts were counted in three specimens selected at random. They were also found in the mouth, tongue, and eyes but were not counted there.

and Hunter and Hunter have twice reported black cysts on trout in New York State. In one instance from Lake Titus they refer to them as Strigeids (13). In the other, from Canopus Creek, they term them only "Black spots" (12). A rainbow trout (*Salmo irideus*) from the collection of the late Mr. Atkinson from the Lake Commandant area shows cysts similar to those of *A. imperator*. Whether these are the same parasite and identical with *A. imperator*, it is impossible to say, but the two are certainly very alike.

A paper presented by Linton (17) at the International Zoological Conference in 1907 is of interest in view of the present information. At that time he reported a black-spotting infection of trout from Alder Lake in the Catskills. The limited information and conditions he gives suggest that the metacercaria he found were not heterophyids. The cysts were larger than those of the present form, and he saw structures in the metacercariae that were probably oral and ventral suckers and holdfast organs. This fact, and the part apparently played by kingfishers, suggest that his material was of strigeid relationship. This supposition is further supported by the presence in Alder Lake of potential snail vectors of this family. One small metacercaria in which he noted only an oral sucker and a pharynx could possibly have been a heterophyid but this cannot be judged with any certainty.

All the speckled trout (*Salvelinus fontinalis*) caught from Lake Commandant were infected. The part other fish might play in maintaining an infection is of interest. Several yellow perch (*Perca flavescens*) and common suckers (*Catostomus commersonii*) (usually found associated with infected trout) failed to show any evidence of heterophyid infections. Similarly lake trout (*Cristivomer naymaycush*) seemed free. These fish were all carefully examined, then subjected to artificial digestion. No cysts were recovered.

The Egg (Fig. 2).

The egg is brownish yellow and oval in shape, usually narrowed at the operculated end and rounded at the other where a small protuberance often occurs. Variations to this general scheme are common. Size is fairly uniform, 0.028 by 0.16 mm. to 0.034 by 0.017 mm. Some are embryonated when voided by the host but all contain miracidia within three weeks. Hatching was not accomplished in the laboratory and mechanical rupture of the egg always destroyed the miracidium.

Experimental Investigations

An effort was made to identify the snail-vector. It has been shown previously that related genera require an operculate snail for development. By far the commonest snails in the infected waters are *Amnicola* sp., but exposure experiments with these snails and hatchery-raised trout have been unproductive. A small variety of *Campeloma* found in the lake was also used in this way with a similar failure. Trout and other fish were exposed to the snails of the non-operculate genus *Helisoma* taken from Lake Commandant. In this case the trout remained uninfected but black pigmented strigeid cysts developed in the other hosts.

In an effort to judge what might be the natural final host of this organism, various laboratory animals were fed cysts or infected fish (Tables II and III). The birds and rodents used had all been raised in the Institute. The cats came partly from the Poultry Department, Macdonald College, and partly

TABLE II

INFECTION TRIALS WITH EXPERIMENTAL ANIMALS

Host	Period of infection	Result of faecal examination	Result of post-mortem examination	Remarks
Cat	7 weeks	Positive	Adult *A. imperator* in small numbers	Cat fed eviscerated trout
Cat	7 days	—	Immature *A. imperator*	
Cat	10 weeks	Positive	—	Faecal examinations negative until fourth week and after tenth week
Cat	12 days	—	Adult *A. imperator* recovered	
Pigeon	7 weeks	Positive fifth week	Adult *A. imperator* recovered	Fed cysts only
Pigeon	12 weeks	Positive sixth week	Negative	
Duck	12 weeks	—	Negative	—
Duck	8 weeks	May have been positive at six weeks	Negative	A single egg was recovered from this duck
Duck	6 weeks	Negative	Negative	Fed filleted fish: (all the other birds were fed cysts only)
Chick	6 weeks	Negative	—	These chicks were 2 to 3 weeks old when fed cysts
Chick	5 weeks	Negative	Negative	
Heron	8 weeks	—	Negative	
Porcupine	4 weeks	—	Negative	Fed diced cyst-bearing fins

TABLE III

SMALL RODENT INFECTION TRIALS

Rodent	Interval between attempted infection and post mortem	Results			Remarks
		Intestine	Other organs	Faecal examination	
Guinea pig	5 weeks	Negative	Negative	Negative	Fed diced skin and fins, containing many cysts
Guinea pig	11 days	Negative	Negative	Negative	
Mouse	3 weeks	Negative	Negative	Negative	Fed cysts only
Mouse	2½ weeks	Negative	Negative	Negative	Fed diced infected skin
Mouse	2 weeks	Negative	Negative	Negative	Fed diced infected skin
Mouse	5 days	Negative	Negative	Negative	Fed diced infected skin
Mouse	3 days	Negative	Negative	Negative	Fed cysts only
Mouse	12 hours	Negative	Negative	Negative	Fed diced infected skin

from a known source at Kirkdale, Que. In no case had any experimental animals previously eaten fish.

In the experiments the intestine was examined in four sections, duodenum, remainder of small intestine in two equal portions, large intestine. No adult flukes were ever taken from the large intestine or duodenum, and most were found in the latter part of the small intestine.

The results of these attempts to infect various experimental hosts are notably irregular. They do indicate, however, that both mammals and birds may be parasitized by *A. imperator*, and that absence of eggs in the host faeces does not indicate freedom from infection. The appearance of eggs in faeces was considerably later than the earliest recovery of egg-bearing trematodes. The adult state is reached between the seventh and the twelfth days, and eggs first appear in the faeces almost a month later. Egg production was never very great, but no planned egg counts have been taken except to determine when they might be no longer present.

The table shows that the trematodes are not recoverable from the lumen or mucosa of the intestine after an interval. The exact length of this interval and the final fate of the parasites have yet to be determined.

The attempt to produce infections in small rodents was planned as an investigation preliminary to trials on the effects of heat on the encysted metacercariae, to determine the treatment necessary to make infected fish safe for human consumption. The results were uniformly disappointing. Fish scales were sometimes recovered, some of them still carrying the characteristic black pigment, but no cysts or freed trematodes were ever met with in the lumen or tissue of the intestine, or elsewhere in the animals.

The generic distinction recommended by Ciurea (10), based on the time required for development of egg-bearing adults, will not apply to *A. imperator*. He pointed out that members of the genus *Apophallus* were egg-bearing only

by the fourth day, while eggs could be demonstrated in those of the genus *Rossicotrema* by the second day after infection of the final host. Two extremes for egg-development represented by the writer's material are the metacercariae already mentioned, and non-ovigerous specimens taken from a cat on the eighth day after infection (Fig. 15).

In addition to these experimental hosts, the following fish-eating wild birds from the infected areas were examined with negative results, *Ardea herodias*, *Mergus merganser*, *Lophodytes cucullatus*, *Strix varia*. So far, members of the genus reported from Canada are *A. venustus* from various hosts, and *A. brevis* from the loon, *Gavia immer*.

Conclusions

Experimental observations, study of material, or analysis of literature on the genus *Apophallus* and related genera have shown that:

1. *Salvelinus fontinalis* in Quebec is the intermediate host of *Apophallus imperator* sp. nov., a heterophyid trematode.
2. *A. imperator* will become adult in the latter part of the small intestine of birds and mammals, experimentally in pigeons and cats.
3. The primary host is unknown. Snails of the genera *Amnicola*, *Campeloma*, and *Helisoma* from an infected area failed to cause the condition in trout in experimental trials.
4. The arrangement of the vitellaria, body-shape, position of testes, and period of development do not show adequate generic or specific characteristics in *Apophallus* and associated genera.
5. The position and number of gonotyls are of generic significance in the family Heterophyidae.
6. The nature of the gonotyls is of value in specific diagnosis within the genus *Apophallus*.

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The names of fish are those used by Hubbs (11), birds were identified following Taverner (26), and the names of snails are from the recent check list prepared by LaRocque (15).

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